OLEORESIN EXTRACTION AND PRODUCT DEVELOPMENT FROM WOOD APPLE
(Feronia limonia Swingle*)*

Thesis

Submitted to the
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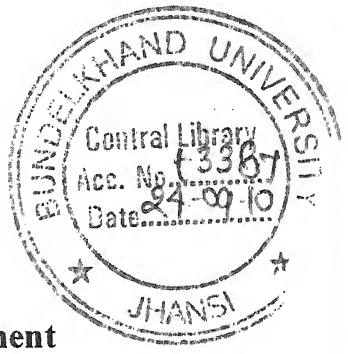

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for the degree of

DOCTOR OF PHILOSOPHY

in

FOOD TECHNOLOGY

by

Abhilasha Jha

Under the Supervision

of

Dr Devendra Kumar Bhatt

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CERTIFICATE

This is to certify that the material embodied in the thesis, entitled ***"Oleoresin Extraction and Product Development from Wood Apple (Feronia limonia* Swingle)"**, has been carried out by Mrs. Abhilasha Jha for the award of Ph.D. degree in Food Technology has been conducted at Institute of Food Technology, Bundelkhand University, Jhansi. It is his original research work under my guidance and supervision. No part of the thesis has been submitted for the award of any other degree/diploma or fellowship or any other similar title or prize to the best of my knowledge. It is further certified that the above candidate was present under my guidance for more than 200 days as required by the Bundelkhand University ordinance during the research work.

The contributions of various sources have been duly acknowledged.

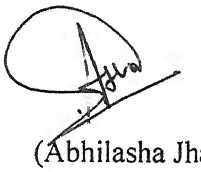
(D.K. Bhatt)
Guide

DECLARATION

I hereby declare that the research presented in the thesis entitled as ***"Oleoresin Extraction and Product Development from Wood Apple (Feronia limonia* Swingle*)"*** for the Ph.D. degree has been conducted by me at Institute of Food Technology, Bundelkhand University, Jhansi.

This is an original piece of work and has not been submitted for any other degree or diploma to any other University. Analysis of existing data, result findings and the ultimate conclusion part has been done by me. At various places of the report my own view points have been incorporated.

I further declare that I have been committed and sincere for this research work



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INTRODUCTION

1. INTRODUCTION

India holds a unique position by growing a number of fruits because of its diversified climatic conditions; fruits of different kinds are available throughout the year. The fruits are important source of vitamins, minerals, fibre, carbohydrate, etc. India with its current production of around 32 million MT of fruit, accounts for about 8 per cent and citrus fruits constitute around 20 per cent of world's total fruit production during 2008. The diverse agro-climatic zones the country makes it possible to grow almost all varieties of fresh fruits and vegetables in India (Post harvest India, 2008). India produces about 11mn tonnes of processed fruits and vegetables, fruit juices, pulp and concentrates (FICCI, 2006). There has been considerable increase in the consumption of fruit juice beverages in the world during the last few years. Fruit juice beverages are considered more as occasional drink in our country. Bottled squashes, nectar and other form of fruit based beverages are looked upon as an expensive indulgence.

Wood Apple is also known as Elephant Apple, Monkey fruit, Curd fruit, *Kath Bel* and other dialectal names in India. Wood Apple (*Feronia limonia swingle* (syns. *Feronia. elephantam correa; Limonia acidissima* L; *Schinus limonia* L.) is a hardy fruit tree grown throughout the country for its edible sweet pulp. Wood Apple belongs to the family Rutaceae. It is a tropical deciduous species, native to India and Sri Lanka. It is commonly found in rural areas as a homestead tree. The name *Ferronia* is very ancient and has been derived after Roman God *Fero*.

There are two varieties of Wood Apple fruit, one with large sweetish fruit, one with small acid fruits. Wood Apple (*Feronia Limonia* L.) is one of the fruits of this category and is available in abundance in winter and early summers all over India. In India, the fruit ripens from early October through March.

Wood Apple is a fruit crop of considerable importance in India. All parts of Wood Apple tree are useful. Wood Apple erect and slow growing tree bearing fruit is round to oval, 5-12.5 cm wide, with a hard, woody, grayish- white, scurfy rind about 0.5 cm thick. The pulp is brown, mealy, odorous, resinous, astringent, acid or

sweetish, with numerous small, white seeds scattered through it (Morton, 1987). It has several medicinal properties. It is antiscorbic (prevent scurvy), a disease caused by lack of vitamin C (ascorbic acid). It is antidote for poison and also helps in curing sore throat (Rao, 2004).

The fruit has hard shell, sticky texture and numerous seeds, which makes it difficult to eat by hand. The scooped out pulp, though sticky, is eaten raw with or without sugar. It is blended with coconut milk and palm sugar syrup and used as a beverage, or frozen as an ice cream. It is also used in chutneys and for making jelly and jam. It plays important role in treatment of diarrhea and dysentery. The fruit are very rich in iron, protein and minerals, especially calcium and phosphorus (Rao *et al.*, 1989). The flesh is refreshing and, aromatic and tastes sour-sweet. The excellent flavor, nutritive value and medicinal characteristics of fruit indicate its good potentiality for processing into valuable products. The pulp is edible and is frequently used in the Indian cookery. The pulp contains 3-5% pectin and forms an excellent material for jelly with agreeable flavor and consistency.

Srivastava and Vatsya (1986) investigated that the Wood Apple beverage produces cooling effect in the same way as Bael. However, Extraction of pulp is the major bottleneck in making of beverage from Wood Apple and that is mainly due to its compact, fibrous and mucilaginous flesh which also contains numerous seeds.

Wood Apple (Elephant apple) is used like Bael for therapeutic and nutritional point of view. The ripe fruit is employed in gum and throat infection. The leaves have an odor like anise and are carminative. Externally applied the pulp and dried rind are employed for the bites of poisonous insects. Thus, value added product if taken up in large scale manufacturing would also open new routes for utilization of this uncultivated and neglected fruit, Wood Apple.

Fruit bar (leather) is a dried-fruit treat, chewy, flavorful, nutritious and delicious confectionary product produced from pulpy fruits such as Mango, Banana, Papaya and guava etc. When water is removed from fruit pulp by drying, addition of sugar, acids, fiber and many vitamins and minerals become concentrated in the remaining solid part of the fruit thus bar/leather is obtained. Fruit bar or slab or leather is the term used for the products prepared by dehydration of fruit pulp with or without

acid and sugar. This makes dried fruits high in sugar and other nutrients too. Dried fruits provide a nutrious way to satisfy a sweet tooth. Fruit bars offer tremendous advantage owing to simplicity and lower inherent cost in production with better consumer appeal.

Preparation of fruit leather from a variety of fruits such as Chiku, Jackfruit and apple has been reported by Cheman and Taufir, (1995); Summers, (1994). Variety of Mango and consistency of the puree had an effect on the quality of bar and pulpy varieties were better suited for its preparation (Nanjundaswamy *et al.*, 1976).

Mango is utilized in the production of a wide range of preserved products. Dried Mango pulp or Mango sheet /leather, popularly called "AMPAPAR", "TANDRA".

Fruit beverages are becoming increasingly popular in comparison to the synthetic drinks because of their taste, flavour and nutritive value. Beverages are an integral part of human diet. The cycle starts with the infant formulas-highly complex drink, rich in many key nutrients. As human ages and their nutritional requirements changes, product designer keeps pace by developing new and innovative beverages to meet these needs. In India, traditional cuisine includes drinks, which were developed primarily to provide aesthetic appeal, though they also contain certain components having nutritional and therapeutic values. In the course of time these traditional health drinks vanished and for a long period the Indian beverage industry was dominated by aerated synthetic drinks. However, the situation has changed dramatically, the aerated soft drinks, which had registered a whopping 20 per cent growth during late 90's, could manage its present share in market against possible slide. In contrary to this last few years have witnessed a significant development in fruit based beverages. Newly introduced fruit beverages fall into the category of functional foods or neutraceuticals. Energy drinks, isotonic (sport) beverages, herbal and green teas, fortified water, caffienatted drinks and recreational soft drinks are some of the functional beverages, which have gained popularity in recent years.

Fruit juices are excellent sources of carbohydrate, vitamins and minerals but they lack in certain nutrients like proteins and quality fats. Hence, they are not considered as nutritionally rich and have to compete with others as thirst quencher in

the market. Growing health consciousness among the consumer, availability of new flavours and blends, innovation into packaging and other technological developments are expected to push up the per capita consumption of fruit based beverages (Epeson and Bhowmik, 1992).

The blending of fruit drinks could be an economic requisite to utilize profitably some fruit varieties for processing. It is reported that blending of fruit juices help in improving nutrients in the blends and lead to new product development (Kalra *et al.*, 1981). Efforts have been made to prepare blended products from Mango and Pineapple (Begum et al., 1983), Mango and Papaya (Kalra et al., 1991), Guava and Papaya (Tiwari, 2000) and some other fruits.

Various workers (Tripathi *et al.*, 1992, Attri *et al.*, 1998) have reported that two or more fruit juice/pulp may be blended in various proportions for the preparation of more palatable and nutritious nectar, RTS beverages, etc. Moreover, there is always a demand from the consumer all over the world for new products, which should be nutritious and delicately flavoured. The objective of blending may include increase in acceptability of product by providing good taste and flavour and up gradation of nutritional quality. A number of fruits like Aonla pulp, Watermelon, Guava, Pear, etc., that are otherwise little utilized for preparation of beverages, after mixing with other fruit in appropriate proportions provide acceptable drinks. Blending of different fruit pulp/juice is an important device to increase the palatability or improve the quality of the product.

Wood Apple pulp was also used for the preparation of powder. It is the dehydrated product and had very long shelf life without any appreciable change. With the addition of Ginger and Aonla powder, the nutritive value also increased.

The scope of the present investigation is to develop new types of fruit bars fortified with other pulp (Mango pulp, Papaya pulp and Ginger pulp). The fortification of pulp improves the sensory quality of the product and also the nutritional quality.

Keeping in the view the above, the present investigation entitled "Oleoresin Extraction and Product Development from Wood Apple (*Feronia limonia* Swingle)" was undertaken with the following objectives.

1. Extraction of pulp from Wood Apple fruit.
2. Extraction of oleoresin.
3. Preparation of fruit juice from extracted pulp (with the help of Enzyme also).
4. Preparation of fruit bar with combination of other fruits (Mango, Papaya and Ginger).
5. Development of fruit nectar
6. Development of blended beverage (cocktail) by mixing of Wood Apple pulp with Mango pulp, Ginger pulp and flavour (cola and orange flavour)
7. Development of carbonated drink of Wood Apple carbonated drink.
8. Preparation of powder with Ginger and Aonla powder.
9. Storage study of the product or 90 days at room temperature.
10. Analysis of proximate composition, minerals, vitamins etc. at 0, 15, 30, 45, 60, 75 and 90 days.
11. Microbiological study for Total plate count, Yeast and Mold count.
12. Sensory analysis and overall acceptability of the products developed.
13. Their quality, sensory, textural and microbial analysis.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 WOOD APPLE FRUIT

2.1.1 Introduction

The Wood Apple, *Feronia limonia* Swingle syns. (F. elephantum correa, Limonia acidissima L. Schinus limonia L.) is the only species of its genus, in the family Rutaceae. Wood–Apple, may be called Elephant Apple, Monkey fruit, Curd fruit, *Kath bel,* Kavat & other dialectal names in India. In Malaya it is *gelinggat* or *belinggai*; in Thailand, *ma-khwit*; in Cambodia, *kramsang* in Laos, *ma-fit*. In French, it is *pomme d' elephant, pomme de bois* or *citron des mois*.

According to the K.N. Rao (2004) the older botanical name indicates the elephant connection in that the specific name is 'Elephantum', an animal that wholly survives on plant parts including the bark of several trees. It is not a surprise that elephants are especially attracted to this fruit. There is more to it than the mere fondness which the elephant have for this fruit. The rural folk believe that the digestive track of the animal has a peculiar capacity for digesting the inner content of the fruit without affecting the fruit's woody rind. So, as the animal defecates, the fruit comes out looking as if it is whole.

The Wood Apple tree is quite common through all the dry districts of India. Rao (2004) also sighted a few of them in the compounds of home institutions and residential bungalows in Chennai. Wood Apple, as one of it's aliases (Elephant Apple) suggest, is the favorite of elephants. Naturally, the Hindu elephant-headed god, Lord Vinayaka, is propitiated with an offering of this fruit.

2.1.2 Taxonomy and Morphology

It is a member of *Rutaceae* family to which citrus and bale fruit belong. Troup (1921) has described Wood Apple as a small-to moderate-sized, deciduous, glabrous tree with thorny branches, growing to a height of 10 m and 0.6 to 1.6 m in girth. The trunk is short, cylindrical with a symmetrical crown of foliage. The bark is dark grey coloured, rough, thick and longitudinally furrowed. Spines are axillary and stout 2.5 to 5 cm long. Leaves are odd pinnate, 15-25 cm long, petiole and rachis flat, often narrowly winged. Flowers are small,

numerous, pole greenish in colors with red ting and appear in terminal or auxiliary panicles, male and female flower often in the same panicle. The calyx is very small with 5-6 lobes and of deciduous nature. There are 5-6 petals, elliptic-oblong, spreading or bent downwards. Stamens 10-12, filaments short, equal, subulate from a broad villous base (Brandis, 1906).

2.1.3 Origin and Distribution

Wood Apple (*Ferronia limonia* L.) is a hardy fruit tree grown throughout the country for its edible sweet pulp. It is native and common in the wild dry plains of India and Ceylon and cultivated along roads and edges of field and occasionally in orchards. It grows wild particularly in dry deciduous forests in the southern and central regions. It is also frequently grown throughout Southeast Asia, in northern Malaya and on Penang Island. It is commonly found in rural areas as a homestead tree. The name *Ferronia* is very ancient and has been derived after Roman God Fero .

Wood Apple is a thorny tree commonly found in dry deciduous forests and cultivated in many parts of India for its fruit. It possesses great tolerance to drought. Extensive root system and synchronization of its reproductive phase with high moisture availability make it suitable crop for arid zone.

2.1.4 Description

Wood Apple is a small deciduous tree with short erect cylindrical trunk. The tree is moderate in size. It grows to a height of 10-12 meter bearing thorny branches then sub divided into slender branchlets drooping at the tips. The bark is ridged, fissured & scaly and there are sharp spines 3/4 to 2 in (2-5cm) long on some of the zigzag twigs. The deciduous, alternate leaves, 3 to 5 in (7.5-12.5 cm) long, dark-green, leathery, often minutely toothed, blunt or notched at the apex, are dotted with oil glands and slightly Lemon scented when crushed. Dull-red or greenish flower to 1/2 in (1.25 cm) wide are borne in small, loose, terminal or lateral panicles. They are usually bisexual. The fruit is round to oval, 5-12.5 cm wide, with a hard, woody, grayish- white, scurfy rind about 0.5 cm thick. The pulp is brown, mealy, odorous, resinous, astringent, acid or sweetish, with numerous small, white seeds scattered through it.

The fruit is 5.0 to 8.0 cm in diameter, usually globose with a woody brownish pericarp, filled with a dark brown sub-acid pulp when ripe. The surface of fruit is very rough and covered with white bloom. Seeds are numerous, oblong, embedded in the edible pulp. Botanically, the fruit is hard-shelled, many-seeded berry. The rind is woody, hence, the name, Wood Apple.

2.1.5 Climate and Soil

2.1.5.1 *Climate*

Natural stands of Wood Apple trees are found throughout the plains of India. It grows luxuriantly in dry climate and is found growing up to an elevation of 1,500 ft (450m) in the western Himalayas. It is said to require a monsoon climate with a distinct dry season. It is mostly grown in dry region of subtropical and tropical region of the country. It does not grow well above 1500 m. The mature plants can tolerate low temperature (0-15°C) as well a temperature as high as 47.5°C (Troup, 1921). The warm season appears conducive for the initiation of floral buds. The tree sheds its leaves and the branches are bare for a short period in the cold season during January and the flowering starts in February-March. It is commonly found in the semiarid tracts of Karnataka, Maharashtra and Madhya Pradesh.

2.1.5.2 *Soil*

It can grow in a wide variety of solids including degraded soils of arid region and can tolerate salinity to certain extent. The tree shows a marked preference for black cotton soils for its optimum growth and fruiting. It can be grown successfully in marginal lands. The tree grows well in deep well drained soil. It prefers slightly acidic soils but can grow even on soil with high pH and rocky soils.

2.1.6 Propagation and Seed

The wood-Apple is generally grown from seeds though seedlings will not bear fruit until at least 15 years old. Wood Apple can be propagated by seeds or by cutting or by root suckers, layering and budding. Budding is one of the most promising method of propagation in Wood Apple. Budded trees tend to be dwarf and bear fruits early. When seedling are raised from seeds, they are retained in the primary bed for two months or until, they produce 3 sets of leaves & then transplanted in polythene bags filled with compost, sand and red earth in 1:1:1 proportion. The bagged seedling

are kept in shade and watered daily.

These seedlings will be ready for planting in about 5 to 6 months time. The seedlings grow very slowly and can be maintained up to 2 years in the polythene bags. Seed sown fresh usually show high percentage of germination (66%). About 31,000 can be raised from a kilogram of seed (Troup, 1921). Seedlings are transplanted a year later. Polyembryony to the extent of 63 per cent is observed in Wood Apple. Polyembryonic seedlings are vigorous in growth and breed true to type.

2.1.7 Flowering, Pollination and Floral Biology

In Wood Apple, numerous small flowers are borne on terminal or axillary panicles mainly on new shoots. Emergence of panicles commences in the middle of February and continues upto 3rd week of May. Opening of flowers starts in the 2nd week of March. The flowers are mainly staminate and hermaphrodite. Ovary, style and stigma are present in both hermaphrodite and male flower but rudimentary in the latter. Both perfect and staminate flowers have 10 to 12 stamens of equal size. The anthers are basifixed dehiscing through a slit between the two pollen sacs of each lobe. The fresh pollen grains are dark yellow.

Size of pollen grains ranged from 28.4 to 36.1 microns. Sucrose (20%) was found better medium for pollen germination. Wood Apple is a highly cross pollinated crop. Pollination is done by insects and unpollinated flowers failed to set fruits. No evidence of bud pollination or parthenocarpy was noticed.

2.1.8 Season

In Malaya, the leaves are shed in January, flowering occurs in February and March, and the fruit matures in October and November. In India, the fruit ripens from early October through March.

2.1.9 Varieties

There are two types, one with large, sweetish fruit & one with small, acidic fruit. The physio-chemical data on fifteen local strains of Wood Apple from Rahuri (Maharashtra) the weight of the fruit, pulp content and rind thickness varied from 173 to 540 g, 58.0 to 75.93 per cent and 0.2 to 0.5 cm, respectively and the total soluble

solids, acidity and total sugar ranged from 14 to 18.5 per cent, 1.04 to 4.5 per cent and 4.08 to 8.47 per cent, respectively among the genotypes observed. It appears that the organoleptic quality of Wood Apple pulp depends upon the Brix: acid ratio. Higher value make the fruit pulp more palatable. The evaluation suggested that the superior strains genotypes No. 5, No. 9, No. 10, and No. 15 hold promise for future cultivation the Marathwada Agricultural University (MAO), Parbhani, Maharashtra, has released a type called HB-10 having large-sized fruits. Average weight of fruit is 350 g having 224g pulp (Gopalan, 1994).

2.1.10 Planting

It is a very useful tree for planting in waste land, boundaries of farm lands, farm bunds, in tree grooves, hill sides and slops in very low rainfall area. It can be conveniently grown as a homestead tree in the compounds and back yards of house. The best time of planting is June and July or just before the onset of monsoon. Pit planting is preferred in the plains. If the trees are grown in plantahions, pits of 0.5 x 0.5 x 0.5m are dug at a spacing of 5m. The pits are filled upto about ¾ from the bottom with top soil and small quantities of manure. The container grown seedlings are planted at the center of the pit after carefully removing the polythene bag. If spacing given is 4 x 4 m, 625 trees per hectare can be accommodated. If it is 5 x 5m, 400 trees per hectare can be accommodated. If there is dry spell soon after planting, the plants are to be watered until they get established.

2.1.11 Harvesting and Yield

2.1.11.1 *Harvesting*

The tree comes to bearing after about 10 to 12 year from planting. The fruit is tested for maturity by dropping on to a hard surface from a height of 1 ft (30 cm). Immature fruits bounce, while mature fruits do not. After harvest, the fruit is kept in the sun 2 weeks to fully ripen. On an average a well grown tree bears about 400 to 800 fruits per year.

Flowering in Wood Apple takes place from February to May and ripe fruits are available from October to March. In fact, the period of flowering and fruiting is governed by climate and the period of moisture availability. The stage of harvest is determined by the purpose of using the fruit. For *chutney*, immature but fully

developed fruits are preferred; however for squash and jelly, fully matured fruits are desirable.

Proper care is required for harvesting the fruits. A minor crack on the rind can cause spoilage during storage. At maturity the grip of fruit stalk is loosened and the fruit is detached from the tree without any efforts which otherwise is difficult in unripe fruit. The stem end of the fruit is vulnerable to fungal infection.

2.1.11.2 *Yield*

A vegetatively propagated tree starts bearing at 3 years. However, it takes about 10 year for a tree to provide optimum production. Yield varies considerably but a grown up tree can produce about 200 to 250 fruit per annum. Fruit can be graded on the basis of size and marketed. The fruit has ready market and sells at about 50 paise to 1 rupee depending upon the size of the fruits. An average income of Rs. 20.000/ - can be expected from a hectare of Wood Apple tree.

2.1.12 Storage and Post Harvest Technology

In general, Wood Apple fruits have a good post harvest strong life because of its hard outer shell and it can withstand transport and marketing hazards.

2.1.13 Composition

The ripe fruit contain sour-sweet, chromatic pulp which is about 70 per cent of total weight. Wood Apple pulp contains significant amount of protein. The fruit is a rich source of riboflavin, acidity is about 2.5 per cent and sugars 7.2 per cent. The composition of Wood Apple fruit is presented in Table 2.1. The pulp represents 36 per cent of the whole fruit. The pectin content of the pulp is 3 to 5 per cent (16 per cent yield on dry-weight basis). The seeds contain bland, non-bitter, oil high in unsaturated fatty acids. The Wood Apple fruit contains 47-58 per cent shell (average 53 per cent) and 32-38 per cent pulp (average 36 per cent).

Table 2.1: Composition of Wood Apple fruit*

Constituents	Value /100g edible portion	Mineral content	Mg/100g fresh weight	Vitamin content	Values/100g fresh edible portion
Moisture	64.2 g	Calcium	4	β-Carotene (µg)	61.0
Protein	7.1 g	Phosphorus	9	Thiamine (mg)	0.04
Carbohydrates	17.0 g	Iron	0.5	Riboflavin (mg)	0.17
Fat	0.3 g	Magnesium	41	Niacin (mg)	0.8
Tot. Minerals	0.3 g	Copper	0.21	Vitamin C (mg)	3.0
Energy value (kg Ca/µg)	74	Manganese	0.18		
		Zinc	0.46		

*Anonymous (1956).

2.1.14 Oleoresin

Oleoresin is the highly coloured viscous oil which embodies all the quality factors of spices like characteristics pungent taste, aroma and colour. This oleoresin (extractive) extracted by solvent extraction method and contains the essential oil and the non- volatile resinous matter (Shankarikutty *et al.*, 1982).

According to the Ramakrishna *et al.* (1979) Indian Wood Apple seed (*Feronia elephantum* Correa) constituting 6% (dry weight basis) of the fruit, contains 34% oil and 28% protein. The kernel comprises 62% of the seed. The characteristics and composition of Wood Apple seed are given in Table 2.2. The characteristics of Wood Apple seed oil are given in Table 2.3. The oil is yellow with an iodine value 131, saponification value 192, unsaponicable matter 1%. Fatty acid profile of oil by GLC is: palmitic 19.3, stearic 7.3, oleic 27.2, linoleic 19.8, linolenic 26.4% (Table 2.4).

2.1.14.1 *Papper oleoresin*

White Pepper gives an attractive golden brown oleoresin which is high in oil and piperine content. However, the high cost of raw material and the lower yield of oleoresin make it uneconomical. White Pepper oleoresin is preferred in special

preparations such as white sauce, fish and meat dishes. Pin heads are unsuitable because of its very poor content of volatile oil and piperine (Shankarikutty *et al.*, 1982). Freshly prepared Pepper oleoresin is a dark green, viscous heavy liquid with a strong aroma.

2.1.14.2 *Chilli oleoresin*

India is the major produced of the raw spice, export of Chilli oleoresin is done only in a very limited scale. Oleoresin contains both pungency and colour of the Chilli. The main active principle is the pungency contributing compound capsaicin, which is present to the extent of 0.2-1.0 per cent in the Chilli (Mathew *et al.*, 1971a). The red colour is due to the carotenoids pigments which are present to the extent of 0.2- 0.5 per cent in the spice (Krishnamurthy and Natarajan, 1973).

Table 2.2: Characteristics and composition of Wood Apple seed

Seed size:	
Length mm (AV)	7.0
Breadth	4.0
Thickness mm (AV)	2.5
Seed index, wt. of 100 seeds, g	3.0
Moisture, %	4.0
Oil, %	34.0
Free fatty acid of extracted oil (% oleic)	0.7
Total protein, %	28.0
Total ash, %	4.0
Crude fiber, %	19.0
Hull / kernel ratio of the seed	38.62

Table 2.3: Characteristics of Wood Apple seed oil

Charcteristics	Wood Apple seed oil
Specific gravity at 37.5°C	0.9149
Refractive index at 25°C	1.4674
Iodine value (wijs)	131
Acid value	1.5
Saponification value	1.92
Unsaponiflable matter, %	1.0
Color	Yellow with Orange tinge

Table 2.4: Fatty acid composition (by GLC) of Wood Apple seed oil

Fatty acid	% by weight
Palmitic	19.3
Stearic	7.3
Oleic	27.2
Linoleic	19.8
Linolenic	26.4

2.1.14.3 *Ginger oleoresin*

Ginger Oleoresin is the product obtaind by solvent extraction of the dried rhizomes of *Zingiber officinale* L. Roscoe (Family-Zingiberaceae), with the subsequent removal of the solvent. Ginger oleoresin is pleasant smelling, dark brown viscous oil. It contains the volatile essential oil and Gingerol, the pungent principle (Lewis *et al.*, 1972). The essential oil content of Ginger oleoresin can vary from 15 to 35 per cent. Minimum volatile oil content in oleoresin should be 18-35 ml per 100g (Anonymous, 1965b).

Gingerol is a mixture of the homologues of (4- hydroxyl, 3- methoxy phenyl 5-hydroxyl-alkane-3 ones) (Connell and Sutherland, 1969). The same workers found that apart from Gingerols, small quantities of shogaol, Gingerone, and traces of paradol were also found present in oleoresin. Besides oil and Gingerol, Ginger oleoresin contains resins, fats, carbohydrates and colouring matter. Upto 30 per cent non pungent residues were found. Gingerol was found to constitute about one-third of a good quality acetone extracted oleoresin from Australian Ginger (Connell and Sutherland, 1969).

2.1.15 Volatile Flavor Component of Wood Apple

MacLeod and Pieris (1981) investigated that the nature of the volatile flavor component of Wood Apple fruit and a processed product. Wood Apple (*Feronia limonia*) has not before been analyzed for its volatile flavor components. The brown edible pulp of the fruit is enclosed within a rough woody pericarp, and is possesses a most characteristics and unusual flavor. It is quite pleasant but with an odd, slightly fatty undertone such that it might not appeal to all palates. The fruit is widely consumed as such but the pulp is also used for making cordials, cream, and jelly, all of which retain the unusual flavor to some extent. Wood Apple has recently become an economically important commodity in Sri Lanka because the cream is now canned and exported.

Representative samples of the aroma volatile of Wood Apples - a tropical fruit and a canned, processed product (Wood Apple cream) were obtained by means of a modified Likens and Niokerson apparatus using trichlorofluoromethane as the solvent. Extracts were concentrated by a low-temperature-high-vacuum distillation procedure, and components of resultant essences were identified as far as possible by GC-MS using both EI and CI mass spectrometry. Odour evaluation at an odour port during GC revealed three components described as having characteristics Wood Apple aroma methyl hexanoate, ethyl 3-hydroxyhexanoate, and butanoic acid. Most aroma components were esters (~15% of the total samples) and included β-hydroxyl esters which have previously only been located in tropical fruits. Two similar series of chemically closely related compounds were recognized, together comprising ~70% of the samples. Overall Wood Apple cream provided very similar results to Wood Apple fruit and was therefore a good preserved substitute.

2.1.16 Extraction of Pulp

The flesh is refreshing, aromatic and tastes sour-sweet. Excellent flavor, nutritive value and medicinal characteristic of fruit indicate its good potentiality for processing into valuable products.

According to Srivastava and Vatsya (1986) Wood Apple beverage produces cooling effect in the same way as Bael. However, extraction of pulp is the major bottleneck in making of beverage from Wood Apple and that is mainly due to its compact, fibrous and mucilaginous flesh which also contain numerous seeds. Some fruits with similar characteristics have already been successfully converted into pulp by passing the heated or unheated fresh-water blend through muslin cloth or a pulper. Several workers have standardised flesh to water ratio for obtaining pulp from various fruits which was 1:0.25 to 1:0.67 for Phalsa (Anand, 1960 and Ambadan, 1973), 1:1 for ber (Singh and Dhawan, 1983), 1:1 Guava (Singh, 1983), 1:0.25 for Pineapple (Singh, 2000) and 1:0.50 for Jamun (Asharf, 1987). Varying levels of heating of flesh water blends ranging from 50 to 80°C have also been used by many workers for pulp extraction from Jamun (Ambadan, 1973), ber (Khurdiya and Singh, 1975) Bael (Roy and Singh, 1979) Phalsa (Khurdiya and Anand, 1982). Arya and Rastogi (1993) summarized methods of juice extraction from Orange, Lemon, malta, Mango, Pineapple, Mulberry, Phalsa, Jamun and coloured fruits.

Chopra and Singh (2001) investigated that the effect of dilution of Wood Apple thermal treatment of fresh-water blends on the ease of pulping, pulp yield and the chemical characteristic of the extracted pulp. Extraction was difficult when added water was less than one part of flesh. Dilution increased the pulp yield and TSS (Total Soluble Solids) recovery, but lowered the content of TSS, acid and vitamin C in pulp. Pulp yield was decreased significantly with heating of flesh water mix to 80°C. However, thermal application enhanced the TSS recovery and content of TSS and acid in pulp. Flesh to water ratio of 1:2 and heating of this mix to 100°C were found ideal for an easy extraction of pulp.

2.1.17 Food Uses

2.1.17.1 *Raw pulp*

The rind must be cracked with a hammer. The scooped-out pulp, slightly sweet, though sticky, is eaten raw with or without sugar/honey or is blended with coconut milk and plam-sugar syrup and drunk as a beverage or frozen as an ice-cream (Morton, 1987). The pulp is sweetened with *gur* or sugar and eaten fresh and can be freeze-dried for future use but it has not been satisfactorily dried by other method.

2.1.17.2 *Jelly and jam*

The pulp contains 3.5 per cent pectin and forms an excellent material for making jelly and jam. The jelly is purple and much like that made from black currents. Being rich in pectin, it makes good jelly. Jelly provides calories, ascorbic acid and iron prepared by Joshi and Jain (2008).

2.1.17.3 *Beverages*

Fruits were deshelled by hand and the pulp with seeds were mixed with required quantity of water and boiled twice, for extractions from pulp. Brix was raised to 13°Brix by addition of sugar from its original 7°Brix. The prepared juice after boiling for 30 minutes was filled into cans, while it was still hot, by using stainless steel ladle. Then the cans were sealed by a hand machine and sterilized in boiling water bath for 30 minutes cooled and stored at room temperature. A bottled nectar is made by diluting the pulp with water, passing through a pulper to remove seed and fiber, further diluting, straining and pasteurizing. A clear juice for blending with other fruits juices, has been obtained by clarifying the nectar with Pectinol R-10. Pulp sweetened with syrup of cane or palm sugar, has been canned and sterilized (Morton, 1987). It can be used as adjunct in making squash (Gopalan, 1994).

2.1.17.4 *Wood Apple burfi*

Sakate *et al.* (2006) standardized a method for preparation of Wood Apple *burfi*, cow milk *khoa* and various levels of Wood Apple pulp viz. 20, 30 and 40 per cent (by weight) and 45 per cent sugar. It was observed that 20 percent Wood Apple pulp with 45 per cent sugar produced desirable product. Incorporation of Wood Apple pulp in *burfi* not only improved the sensory quality but also reduced the cost of production by about 10 per cent.

Table 2.5: Food value per 100gm of edible pulp*

	Pulp (ripe)	Seeds
Moisture	74.0%	4.0%
Protein	8.00%	26.18%
Fat	1.45%	27%
Carbohydrates	7.45%	35.49%
Ash	5.0%	5.03%
Calcium	0.17%	1.58%
Phosphorus	0.08%	1.43%
Iron	0.07%	0.03%
Tannins	1.03%	o.08%

*According to analysis made in India.

2.1.17.5 *Wood Apple syrup*

Fruits are deshelled by hand and the pulp with seed are mixed with required quantity of water and boiled. Two extractions from the pulp are made. TSS is raised to 13°Brix by addition of sugar from its original Brix. The prepared juice after boiling for 30 minutes is filled into cans while it is still hot. The cans are sealed and stored at room temperature for more than $1^1/_2$ years (Gopalan, 1994).

2.1.17.6 *Fruit jelly*

Joshi *et al.* (1985) prepared fruit jelly by using acidic whey obtained after separation of chakka and fruit pulps of Wood Apple (*Feronia elephantum*), Guava (*Psidium quajwa)* and kumquat (*Chitrus japonica*) in different proportions. The Wood Apple jelly was found to have proper set, in case of 1:2 proportion of water as well as whey.

2.1.18 Other Uses

2.1.18.1 *Rind*

The hardy dry shells of the fruits are made into snuff boxes (Gopalan, 1994) and other small containers.

2.1.18.2 *Gum*

The trunk and branches exude a white transparent gum especially following the raining season. It is utilized as a substitute for, or adulterant of, gum arabic, and is also used in making artists water colors, ink, dyes and varnish. The transparent gum that exude from the trunk is used as a substitute for gum arabic for making artist water colors, dyes and varnishes. It consists of 35.5% arabinose and xylose, 42.7% *d*-galactose, and traces of rhamnose & glucuronic acid.

2.1.18.3 *Wood*

The wood is yellow-gray or whitish, hard, heavy, durable, and valued for construction, pattern-making agricultural implements, rollers for mills, carving, rulers, and other products. It also serves as fuel. The heartwood contains ursolic acid and a flavanone glycoside, 7-methylporiol-β-D-xylopyranosyl-D-glucopyranoside.

The timber of this tree is largely used for preparing agricultural implements, naves of wheel, oil crushers, house building, ornamental carving, shoe lasts, pen holders, rulers and similar domestic articles.

2.1.19 Medical Uses

The Wood Apple has several medicinal properties. It is antiscrobic, i.e. it prevents scurvy, a disease caused by lack of vitamin C (ascorbic acid). The fruit is much used in India as a liver and cardiac tonic, and, when unripe, as an astringent means of halting diarrhea and dysentery and effective treatment for hiccough, sore throat and diseases of the gums.

It is an antidote for poisons, is poulticed onto bites and stings of venomous insects, as is the powered rind. Juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. The powdered gum, mixed with honey, is given to overcome dysentery and diarrhea in children. Oil derived from the crushed leaves is applied on itch and the leaf decoction is given to children as an aid to digestion. Leaves, bark, roots and fruit pulp are all used against snakebite. The spines are crushed with those of other trees and an infusion taken as a remedy for menorrhagia. The bark is chewed with that of *Barringtonia* and applied an venomous wounds. The unripe fruits contain 0.015%

stigmasterol. Leaves contain stigmasterol (0.012%) and bergapten (0.01%). The bark contains 0.016% marmesin. Root bark contains aurapten, bergapten, isopi-mpinellin and other coumarins.

The importance of Wood Apple fruit lies in its curative properties, which make the tree one of the useful medicinal plants of India (Kirtikar *et al.*, 1935). Its medicinal properties have been dealt within *Chark Samhita* and *Sushruta Samhita*, two early medical treatise in Sanskrit. It has a great demand from native system of medicine such as Ayurvedic. Fruit is used as stomachic and stimulant while leaves are carminative. Bark is prescribed for biliousness. Pulp is applied extremely as a remedy for bites of venomous insects and reptiles.

2.2 BAEL

Bael (*Aegle marmelos* Correa) is an important indigenous fruit of India, belongs to the family *Rutaceae*. Bael fruit occupies an important place although there is no organised orcharding of this fruit in the country. It has been known in India from pre-historic times. According to Hindu custom, its aromatic trifolitale leaves are traditionally used as sacred offering to 'Lord Shiva'. There is mention of Bael fruit in Vedas, Ramayana and also in Buddhist and Jain literatures. In India, it is found growing as wild in Uttar Pradesh, Madhya Pradesh, Orissa, Bihar and West Bengal. There is no systematic plantation of Bael fruit except in Uttar Pradesh. However, this fruit tree has a great potential for plantation in dry belts of Haryana and Rajasthan. The main cultivated varieties are Mirzapuri, Kagzi, Etawah, Kagzi gonad, Kagzi Banarsi, Narendra Bael -1 and Narendra Bael -2.

Bael fruit is one of the most nutritious fruits. No other fruit has such a high content of riboflavin (1.19 mg/100g edible portion) as is found in this fruit. Marmelosin, a potent drug, is probably the most therapeutically active principle of Bael fruit. All parts of this fruit tree viz. root, bark, leaves, flowers or fruits are used for curing one or the other human disease. The roots are sweet, astringent, bitter and febrifuge. They are useful in curing dyspensia, dysentery, diarrhea, vomiting, stomachalgia, intermittent fever, seminal weakness, uropathy and gastric irritability in infants. The bark decoction is administered in malaria fever. The leaves are useful in treating ophthalmia, inflammations, catarrh, deafness, diabetes, and asthmatic

complaints. The flowers allay thirst and vomiting. The unripe Bael fruits are used for curing, dysentery, diarrhea and stomachalgia. The ripe Bael fruits are sweet, aromatic, cooling, laxative, good tonic for heart and brain and cure of dyspepsia.

Bael fruit is difficult to eat out of hand due to its hard shell, mucilaginous texture, numerous seeds and fibers in pulp. Therefore, it is not popular as a fresh fruit. Although, fruits contain very rich aroma which is not destroyed even during processing. Thus, it has a great untapped potential for processing into several value added products. Further, Bael fruit flavor is entirely unknown in national and international markets. So, value added products from Bael can attract both internal and export markets because there is always a demand from consumers all over the world for new food products which are highly nutritious, medicinally important and delicately flavored.

The Bael tree is very hardy and can be grown extensively under rainfed conditions on marginal soils where other fruit crops cannot be grown successfully. It is useful to the farmers in the form of food i.e. edible fruit, fuel, fodder, oil and medicines. Bael fruit is highly nutritious, but the fresh fruit is not liked much because of eating difficulties due hard shell, large number of seeds and mucilaginous texture. The fruit has excellent aroma which is not destroyed during processing thus there is untapped potentiality for processing Bael into various products. These products being highly nutritive and therapeutically important can be very easily popularised in internal as well as external markets. Green Bael fruits are used for preparing murabba, which is an important Ayurvedic medicinal product and generally prescribed for all types of digestive troubles. Bael squash can be prepared very easily at home by mixing Bael pulp, sugar and acid. Green Bael fruit slices can be dehydrated or sun dried for future use. Bael toffee slab, nectar Bael powder etc can also be prepared (Kaushik *et al.*, 2002).

2.2.1 Extraction of Bael Fruit Pulp

Conventional methods adopted to extract fruit pulp are not applicable in case of Bael fruit, because of the mucilaginous texture of the pulp and the tendency of the pulp to develop off flavors and colour rapidly due to the activity of certain enzymes (Roy and Singh, 1979). Extraction of pulp in certain fruits becomes difficult without

the addition of water.

This is mainly due to mucilaginous texture and tendency of the pulp to develop off-flavour and colour. The Bael fruit pulp was successfully extracted by addition of water equal to the pulp (with seeds and fibre), adjusting the pH to 4.3 with citric acid (titratable acidity 0.5%) and heating at 80°C for 1 minute. The application of heat not only inactivated the enzyme but also helped in dissolving the mucilage uniformly to provide a homogenous pulp.

2.2.2 Preparation of Products

Bael fruits can be processed into several value added products viz. preserve (Murabba), candy, dehydrated Bael, Bael powder, panjiri, jam, slab/leather and toffee. Among these products, preserve, candy, dehydrated Bael, Bael powder and *Panjiri* are prepared from mature Bael fruits during December-February, whereas, Jam, slab and toffee can be prepared from ripe fruits during April-June. Processing techniques of Bael products are described by Rakesh *et al.* (2005).

Roy and Singh (1979) worked on the preparation and preservation of different Bael fruit products. Ripe Bael fruit is not consumed freely of eating difficulty, but it may become popular if suitably processed. The palatability of the extracted Bael fruit pulp was improved by adjusting the Brix to 25°Brix by the addition of sugar without further addition of acid. The Bael fruit nectar (canned) of the composition 35 percent pulp, 25°Brix and 0.3 percent acidity was found to be ideal. Similarly, 50 percent pulp, 50°Brix and 1.0 percent acidity was found suitable for squash. The best quality Bael fruit slab was prepared by adding 10 per cent sugar and 1500 ppm SO_2 to the pulp and drying to moisture content of 14.5 per cent. A quality toffee was prepared by mixing Bael fruit pulp (100 parts) sugar (40 parts), glucose (4.5 parts), skim milk powder (10 parts) and hydrogenated fat (6 parts) SO_2 (1500 ppm) was added before rolling into sheets and the final moisture of the toffee was kept at 8.5 percent. Bael fruit powder was prepared by drying the pulp with 2000 ppm SO_2, moisture percent below 4.0 and then by grinding.

2.2.3 Processing and Storage of Bael Fruit Products

Mishra and Chopra (2006) evaluated that Bael fruit could be successfully

utilized to produce crush and mixed fruit jam. Crush containing 25% Bael pulp, 55% total soluble solids (TSS) and 1% acidity and jam with 45% mixed pulp (Bael to Mango pulp ratio 1:1), 70% TSS and 0.5% acidity recorded the highest organoleptic scores. Acidity and TSS of both the products increased slightly after three and four months of ambient storage respectively, while a gradual increase was observed in the non-enzymatic browning during the storage. Crush and jam were found to maintain acceptable quality (organoleptic score $\geq$ 7) upto five and six months of storage, respectively.

Table 2.6: Food Value per 100g of edible portion

Water	61.5g
Carbohydrate	31.8g
Protein	1.8g
Fat	0.39g
Minerals	1.7g
Carotene	55mg
Thiamine	0.13mg
Riboflavin	1.19mg
Niacin	1.1mg
Vitamin C	7 to 21mg

The storage studies of the Bael fruit products were performed after six month. During storage there was reduction in non-reducing sugars and increase in reducing and total sugars in Bael fruit products. Addition of SO_2 not only improved the initial quality of the Bael fruit slab, toffee and powder but also prevented non enzymatic browning reaction during storage of all the Bael fruit products. The optimum relative humidity for the storage of Bael fruit slab, toffee and powder was found to be 63, 58 and 5 per cent respectively. Practically no change in organoleptic quality was noticed in frozen pulp after six month and in case of other products stored at 37°C the organoleptic quality remained much above the acceptable point (Roy and Singh, 1979).

Kaushik *et al.* (2002) investigated changes in quality parameters during processing and storage of processed Bael fruit revealed that processing caused loss of 51.5, 43.2 and 76.4 per cent ascorbic acid in preserve, squash and dehydrated Bael respectively. Crude protein increased during dehydration while these contents decreased in preserve and squash as compared to fresh fruit. Crude fibre remained unchanged whereas significant losses were observed in total phenols. Storage studies on squash preserve and dehydrated Bael had shown that the quality of all these processed products was satisfactory even after six month storage at room temperature.

2.3 MANGO

Mango (*Mangifera indica* L.) is the most important commercial fruit of India. There are thousands of varieties of Mango grown in different parts of India. The characteristics of each variety vary widely. India is the largest producer of Mango in the world. India with its current production of around 12.733 million tonnes of mango, accounts for around 51 per cent of world's total mango production during 2005 (Chandra and Kar, 2005). Mango produces a wide spectrum of fruit products. The ultimate quality of the Mango products largely depends on the selection of the suitable variety. India exports a huge quantity of Mango nectar and juice.

India is the largest producer and consumer of Mangoes in the world, accounted a share of 41 per cent of the world production in 2003. Fruit production in India has shown a tremendous increase during the last four decades. Mango fruit production constitutes about 70 per cent of total fruit production in world. It has an estimated annual production of about 12 million tones. The country reportedly produces about 50 varieties of Mangoes.

Mango, the "king of fruits" is a delicious, exotic and nutritious fruit. The fruit is used as a desert, as a table fruit between meals and is also processed for preparing a hot of products such as juices, pulps, squash, jam, and pickles. A few popular products from Mango like pulp, juice concentrates, jam, chutney, pickles and dried products are prepared commercially. Mango juice is rich in carbohydrates, minerals, Vitamin C, starch, pectins, carotenoids, but lacks in proteins fat and some essential amino acids.

The Mango fruits are consumed both in raw and ripe state. Raw Mango is used for making pickle, Amchur, Chutney and 'Panna' beverages (Adsule, 1997). Ripe Mango is processed into a variety of products viz. Mango slices in sugar syrup, Mango nectar, squash, juice and jam.

The conventional types of Mango products such as preserved Mango products, canned Mango slices in syrup, canned Mango nectar, juice and pulp, Mango squash, Mango jam, Mango preserve, Mango pickle and Mango chutney occupy a prominent place in our country as well as abroad. Mango pickle and chuteny are traditional export items from India (Nanjundaswamy *et al.*, 1976). With increasing awareness of the food value and dietary role of various food constituents, people are now highly discriminative in selecting products. The market tendency is to select those prepared from natural ingredients (Sagar and Khurdiya, 1998).

2.4 PAPAYA

Papaya (*Carica Papaya*) has rapid growth and short life span. India is the fourth largest producer of Papaya (FAO, 1991) with a production of about 9.05 lack tonnes. India with its current production of around 2.150 million tonnes of papaya, accounts for around 43 per cent of world's total ppaya production during 2005 (Chandra and Kar, 2005). Hence, India is rated as the larger Papaya producer of the world.

This fruit recently has attracted the attention of food processors and some novel processes for the preservation of this fruit have been developed. Brekke *et al.*, 1972; Chan *et al.*, 1975; Wenkam and Miller, 1965 reported that this fruit is an excellent source of vitamin A and C. The color of the fruit varies from yellow to Orange/reddish Orange and the pigments responsible for the attractive color are the carotenoids. Some studies have described the physiological and biochemical characteristics of Papaya fruits (Salunke and Desai, 1984) as well as post harvest storage practices (Ann and Paul, 1990).

2.5 AONLA

The Aonla also known as Indian gooseberry (*Phyllanthus emblica* or *emblica officinalis* Garten) is the major fruit crop contributing a substantial production in

fruits. It is the minor sub-tropical deciduous tree belonging to family Euphorbiaceae. Naturally growing Aonla tree has been reported from India, Ceylon, Malaysia, Cuba, Iran, Java, Pakistan, China, Panama, etc. However, its cultivation is more common in India particularly in Uttar Pradesh, where it is cultivated in the district of Pratapgarh, Raebareli, Varanasi, Kanpur, Allahabad and Sultanpur.

Aonla is an important fruit crop of Indian origin and regarded as sacred by Hindus. It is widely grown in many states of India occupying 50,000 ha area, out of which 35 per cent (17,500 ha) lies in Uttar Pradesh alone (Tewari *et al.*, 2004). The crop has adaptability to marginal soils, needs lower input and gives higher remuneration. It can also be grown easily on problematic soils like slightly saline soils where other fruit crops generally do not thrive.

Aonla is a king of acid fruits which is highly nutritive and is the richest source of vitamin 'C'. Aonla is valued as an antiscorbutic, diuretic, laxative and antibiotic. Due to its high nutritional and medicinal values, it is regarded as sacred tree and has been recognized as 'Aritphal' in ancient literature. Aonla fruit is not consumed in fresh or raw form widely, due to its high astringent taste and it is not so popular as a table fruit (Singh et al, 1995). It's vitamin 'C' content is not oxidized due to presence of tannin and is least destroyed during storage (Chandra *et al.*, 1952).

Its compositional make up makes it of good medicinal value as anti scorbic, diuretic, laxative and antibiotic. The fruit also possesses pronounced expectorant, antiviral, cardi tonic and hypoglycemic activity (Karla, 1988). Due to these medicinal and nutritional properties the fruit offers tremendous scope for processing in to various juice based beverages (RTS drinks). Shere *et al.* (2008) prepared Aonla (RTS) beverage and studied the chemical changes during storage. The importance of this fruit is also due to its high content of tannin i.e. gallotanic acid which on hydrolysis produced gallic acid. The fruit has also been recommended by Ayurveda for balanced diet and sound health and is an important ingredient of same traditional products like Triphala and Chyawanprash. Various other products like dried Aonla fruit, sauce, dried chips, tablets, toffees, powder, hair oil and hair dye etc. could also be prepared. In all these products, the stability of ascorbic acid and presence of astringency in Aonla fruits may be assigned due to the presence of polyphenols or

leucoanthocyanins.

The proximate composition of ripe Aonla fruit is presented in Table 2.7. The total sugars content in Aonla fruit varies from 7.0 to 9.6 per cent, reducing sugar from 1.04 to 4.09 per cent and non-reducing sugars from 3.05 to 7.02 per cent among the various cultivars. Aonla fruit contains about 0.9 per cent protein on fresh weight basis. Srivastava and Srivastava (1964) reported total ascorbic acid to be 682.0 mg/100g pulp. The pulp of fresh aonla was found to contain 200-900 mg per cent of vitamin C (Jain *et al.*, 1983; Srivastava and Srivastava, 1964).

Table 2.7: Composition of Aonla fruit

Moisture	81.20%	Phosphorus	0.02%
Protein	0.50%	Iron	1.20%
Fat	0.10%	Calorified value	59/100g
Mineral matter	0.70%	Vitamin B	30mg/100g
Fibre	3.40%	Nicotinic acid	0.2mg/100g
Carbohydrate	14.01%	Vitamin C	600mg/100g
Calcium	0.05%		

2.6 GINGER

Ginger (*Zingiber officinale*) has been used as a spice and medicine in India and China since ancient times. Ginger is underground stem of the Zingiberous herbaceous plant *Zingiber officinale* and is one of the five most important spices of India, standing next to Chilli, Garlic and Turmeric (Govindarajan, 1982a). It is cultivated in several parts of the world, the most important Ginger producing regions being India, Jamaica, China, Sierra Leone, Niigeria, Japan, Taiwan and Australia. In India, Kerala produces 50 per cent of the total production of the country (Pruthi, 1998).

2.7 DEVELOPMENT OF PRODUCT

2.7.1 Bar

Fruit bars are novel products developed across the country and relished by all categories of people. They serve as instant source of energy and other needed vitamins and minerals. Fruit bars are prepared by drying fruit pulps after attaining acidity and sugar concentration to a desired level. Fruit bars offer tremendous advantage owing to simplicity and lower inherent cost in production with better consumer appeal.

Bar (Thandra) is an age old traditional fruit product (bar) accepted by all age groups (Nanjundaswamy *et at*., 1976; Rao and Roy 1980a). Thandra is a semi-moist food which can be used safely for longer time at room temperature in polyethylene pouches. In addition, it contains sufficient dissolved solute to decrease water activity below that required to support microbial growth. Mango bar (Thandra) has taken an important place in commercial trade not only in India but in other countries too. They were conducted to develop fruit bars from single fruit (Papaya) or in combination of two or more fruit (Papaya, Mango and Pineapple).

Generally the fruit bar preparation is the best method for the preservation of the fruit during glut reason when they are produced in a large amount and the prices are too less and also a large quality of fruit are not destroyed, ruptured or infected. We can use these fruits to prepare bar leather or candy and enjoy the natural flavour and taste of fruit in off-season on manual cost.

Fruit bar is a nutritious and delicious confectionary product produced from pulpy fruits such as Mango, Banana, Papaya and Guava etc. Preparation of fruit leather from a variety of fruits such as Chiku, Jackfruit and Apple has been reported (Cheman and Taufik 1995; Summers, 1994). Variety of Mango and consistency of the puree had a definite effect on the quality of the bar and pulpy varieties were better suited for its preparation (Nanjundaswamy *et al.,* 1976).

Fruit bars which can be prepared by drying fruit pulp after adjusting Brix and acidity offer tremendous advantage in simplicity in processing, low investment and high consumer acceptance. The processes are available for making bars from Mango,

Guava, Banana, Pineapple, and Ber (Arya, 1992). In view of the usefulness of the protein-enriched fruit products, an attempt was undertaken to utilize protein enriched

fruit bars from Sapota (var. Cricket ball) with pulse protein (defatted soy flour concentrate) and their storage behavior was observed.

Fruits like figs (*Ficus carica*), Apricots (*Prunus armwniaca* L.) and Apples (*Malus pumila*) are usually dried by cross flow air drier or by sun drying after sulphiting, but fruits like Mango (*Mangifera Indica* L.), Papaya (*Carica Papaya* L.) etc. cannot be dehydrated by these conventional methods. Mango pulp dried in the form of sheets is marketed in our country as 'Am-papad'.

Fruits bars were prepared by dehydrating fruit pulp in the form of sheets using cross flow hot air drier, cutting them into rectangular pieces and wrapping in cellophane Paper. Wrapped fruit bars were packed in Paper/aluminium foil/ polyethylene laminate or in friction top tins. Improvement in the texture of the fruit bars was effected by the incorporation of pectin and adjustment of the pH. Crystallisation during storage was prevented by the addition of liquid glucose (Mathur *et al.*, 1972).

2.7.1.1 ***Processing of fruit bar/leather***

There are a number of workers on fruit bar such as Apple cloth or leather (Singh *et al.*, 1989) Mango bar (Rao and Roy, 1980), Papaya bar (Aruna *et al.,* 1999), Papaya leather (Cheriyan and Cheriyan, 2003), Apricot soy bar (Chauhan *et al.*, 1993), protein enriched Mango bar (Mir and Nath, 1993; Chauhan *et al.*, 1997). Ammu *et al.* (1976) studied on the freeze-drying of Mango pulp. Baldry *et al.* (1976) preparation drum dried ripe Mango bar. Nanjundaswamy *et al* (1976) found that Mango bar is best prepared at 60-70°C using stage drying. Rameshwar (1979) reported dark brown sun dried product. For drying of the pulp cabinet drying can be used (Beauens, 1974; Teotia *et al.,* 1976). Doreyappa Gowda *et al.* (1995) developed a method by which Mango bar was prepared by adding of sugar (20 per cent), citric acid (0.2 per cent) and KMS (700 ppm) individually or in different combinations. Vijayanand *et al.* (2000) report Guava fruit bar prepared from a new process showed better texture, sensory quality and storage stability. Owen *et al.* (1991) have reported

regarding cutting resistance of a restructured fruit bar as influenced by water activity with a low microbial activity for samples having a water activity less than 0.33. Tolstoguzov *et al.* (1983) reviewed on fabricated foodstuff as multi component gels and discussed the physico-chemical properties of gelling agents. Singh *et al.* (2004) reported the effect of °Brix, sodium alginate and drying temperature on colour, texture and sensory properties of 'Dashehri' Mango leather. Ukkuru and Pandey (2006) also prepared Jackfruit leather. But there is negligible work done on the preparation of Wood Apple bar.

2.7.1.2 *Mango fruit bar*

Ripe Mangoes are ordinarily processed for standardized pulp, Mango slices and pulp based fruit drinks beverages, Mango leather and bars. The Mango processing industry incurs heavy loss from raw to ripening stage to packaging of Mangos resulting in high material cost. The product known as fruit leather by some has been prepared using Mango pulp alone and adding high sugar (60-70%) concentration. Mango pulp blended with corn flour instead of pectin has been used successfully for Am-papad (usual term used for leather/bars) preparation. Normally this product has so far not received the attention as regards to its microbial quality and its longevity the attention as regards to its microbial quality and its longevity in packaged condition.

Mango fruit bar is a fruit confectionary product. The method of preparation is quite simple and involves mainly mixing the Mango pulp with suitable ingredients and then drying the pulp in a dryer using cross flow air drying technique. Variety of Mango and consistency of the pulp have definite effect on the quality of the fruit bar. Pulpy varieties are better suited for preparing fruit bar. Thicker the consistency of the pulp better is the texture of the final product. However, thinner Mango pulp could as well be made use for preparing Mango and Banana mixed fruit bar. For such a product mixing Mango and Banana pulps at the ratio of 3:1 has been found to be optimum. Fruit bar is drying for 20-22 hr at 70°C upto the moisture content 15-16 percent in the final product.

Mango fruit bar contains reducing sugar ranged from 16-32 percent and the total sugar content from 60-70 percent depending upon the varieties. It is rich sugar of β-carotene (provitamin A) and fairly good source of nutritional minerals like iron,

phosphorus and calcium of the six commercial varieties tried. *Badami, Banganapally & Totapuri* have been found to give fruit bar a soft texture, deep yellow Orange red in color with characteristic Mango flavor. Mango bar has been found to be hygroemissive product and keeps well in the range of 50-60 percent relative humidity (RH) without any noticeable change in color, flavor and texture below 50 per cent RH, the product losses its moisture content progressively and becomes hard in texture although the color and flavor are good. At 70 per cent RH and above the product absorbs moisture rapidly and the color and texture are affected much but without so much effect on flavor. Mango fruit bar wrapped in butter or cellophane Paper and stored in air tight this have been found to keep well for about on year at ambient conditions (25-28^{0}C) and about six months at 37°C.

Mango fruit bar can be used in a variety of ways. It can be consumed directly as a fruit confectionery product or cut in to pieces and incorporated into ice-cream as fruit chunks. It can also be cut into small pieces, add calculated amount of water and later blend the mixture to get a ready-to-serve Mango juice. (Nanjundaswamy *et al.*, 1976).

The ideal sugar/acid composition for the preparation of Mango sheet/leather of the Mango, cultivars Baneshan, Bombay green and Dashehari were found to be 25^0 Brix and 0.5 per cent acidity. Addition of pectin at the rate 0.5 per cent in the cultivar Baneshan and 0.75 percent in the cultivar Bombay Green and Dashehari was found to improve the texture of the sheet. Addition of the sugar was found to increase the drying time in all the cultivars, while the addition of pectin had no such effects (Rao and Roy, 1980).

Mir *et al.*, (1993) studied that Mango bar is prepared by drying the pulp of ripe fruits. Addition of ingredients like sugar, citric acid pectin and potassium metabisulphite to pulp facilitates drying, and improves the product quality (Heikal *et al.,* 1972; Jayaraman, 1988; Mathur *et al.*, 1972; Nanjundaswamy *et al.*, 1976; Rao and Roy 1980a). The storage characteristics of Mango bars obtained by drying pulp in air cabinet drier have been studied (Rao and Roy, 1980b).

Mango bar is an important product prepared traditionally from unmarketable, but sound ripe fruits. Traditionally, sun drying technique is employed for preparing Mango bar from ripe fruit pulp (CFTRI 1990). But, the sun dried product is dark brown and the process is unhygienic and lengthy due to coincidence of rainy season with the ripening of Mango fruits (Rameshwar, 1979). Heikal *et al.* (1972) and Mir and Nath (1995a) optimized the cabinet drying process by adding additives like citric acid (CA), potassium metabisulphite (KMS) and cane sugar to Mango pulp. They reported that the retention of colour and flavor improved. Mathur *et al.* (1972) blended Mango pulp with other fruits like Banana, Guava, Papaya, Jamun or Pinepple, pasteurized the blend and used three stage air cabinet drying. Mango-Pineapple bar was reported to be superior to other samples. All the Mango varieties are not suited for the preparation of bar (Nanjundaswamy *et al.*, 1976; Gahilod *et al.*, 1982).

Changes in chemical, textural and sensory characteristics of there types of Mango bars (plain Mango, Mango-desiccated coconut powder and Mango-soy protein concentrate bars) during 90 days storage at -18^{0}C, 27±3^{0}C (65%RH) and 38±1^{0}C (92% RH) were studied. Moisture, acidity and reducing sugars of the Mango bars increased significantly during storage in all the cases. Reduction in total and free SO_2, total carotenoids and beta carotene, and an increase in non-enzymatic browning (NEB) were observed. Losses of carotenoids and non-enzymatic browning were found to be more in unsulphited bars than in sulphited bars. Storage decreased the overall acceptability and textural characteristics.

Commercially tray drying is a common method of preparation of a Mango bar as it overcomes the problem of exposure to open atmosphere and requirement of long processing time. Drying characteristics of fruit pulp have been studied by using tunnel drier (Lodge, 1981) and forced air circulation cabinet dryer (Rao and Roy 1980; Mir and Nath 1993). Drying of sugar rich fruit juice and pulp (Mango pulp) is difficult, mainly due to the low molecular weight sugars and acids present in the pulp (Jagtiani *et al.*, 1988). These materials have low glass transition temperature and due to their low molecular weight the molecular mobility of the materials is high when the temperature is just above the glass transition temperature (Roos, 1995). While drying at temperature normally prevailing in tray dryers, they tend to stick to the trays. To

over-come this problem, addition to drying acid, such as maltodextrin is added to get non sticky product (Bhandari *et al.*, 1997).

2.7.1.3 *Protein enriched fruit bar/leather*

Protein and fat of excellent quality are available in soybeans which could be utilized for enrichment of products, which normally lack in these components. Fruit bar or slab or leather are the terms used for the products prepared by dehydration of fruit pulps. The Mango pulp supplemented with soy slurry had increased protein and fat contents and decreased total acid and ascorbic acid contents. Different combinations of Mango pulp and soy slurry were made to prepare the fruit bar. Product having 70% Mango pulp and 30% soy slurry 14.5% moisture, 11.35% protein and 50.0 mg/100g ascorbic acid.

Chauhan *et al.* (1997) prepared Mango fruit bar with the objective of producing nutritionally balanced product. Apricot-soy fruit bar as a new protein enriched product prepared by Chauhan *et al.* (1993). Mir and Nath (1993) studied the effects of fortification of Mango bar with desiccated coconut powder or soy protein concentrate on change in chemical textural and sensory properties during storage. Vyas and Joshi (1982) prepared a new fortified beverage from Apple juice. Singh *et al.* (2003) studied the quality of Mango bar stored in three types of packaging materials. Cheriyan and Cheriyan (2003) studied on the acceptability and storage behavior of blended Papaya leather.

Protein fortification of Mango bar using soy protein concentrate and coconut powder was studied by Mir and Nath (2000). Mango bar was prepared by raising the total soluble solids (TSS) of pulp to 30°Brix with powder cane sugar, adding 0.6 per cent citric acid and drying in cabinet drier at 63+ 20°C for 14 h. The plain Mango bar contained 2.2 per cent protein and 0.5 per cent ether extractives. Addition of 2 per cent desiccated coconut powder or 4.5 per cent soy protein concentrate (SCP) to the pulp raised the percentage of protein and ether extractive in bars to 2.4 and 4.1 and 11.8 and 0.3 respectively.

2.7.1.4 *Papaya bar*

Though Papaya is a nutritious fruit, it is not widely used in product due to its odd flavor, which is not acceptable to many people (Aruna, 1995). Due to processing the odour of Papaya decreases as the volatiles evaporate and thus becomes acceptable to many consumers (Morales and Duque, 1987).

Papaya could be a promising fruit crop for our country, both as a potential foreign exchange earner and as a profitable crop to the farmer. Unfortunately, this fruit has not caught the fancy of consumers as much as it deserves, mainly because the odour of Papaya is not highly appealing and this also the limitation in the commercial exploitation of this fruit for processing. The blending of fruit product could be an economic proposition to utilize them profitably. Some fruit varieties may not have favourable characteristic for processing and cost viability for product preparation. The possibility of enhancing the flavor and acceptability of Papaya products by diversification have been suggested by Kalra *et al.* (1991).

Fruit leather is a well established product manufactured by dehydrating the fruit puree into a leathery sheet (Raab and Oehler, 1976). Preparation of fruit slabs or fruit leather could be a cost effective method for the preservation of Papaya fruit. Fruit leather preparation was standardized using Papaya pulp alone and blending with Mango pulp for making comparison on the organoleptic qualities.

Papaya fruit bar (Thandra) was stored at room temperature (25-45^{0}C) for nine months and the physico-chemical and microbiological changes were studied during the storage period. It was also stored at different temperatures and organoleptic changes were evaluated by Aruna *et al.* (1999). Sensory evaluation of fruit bar revealed higher deterioration in color, appearance and texture on 6 and 9 months storage at higher temperature. The losses of the total carotenes, β-carotene and Vitamin C were 54, 46 and 43% at the end of the storage period. The products stored for 6 months were found to be superior from the textural and odour point of view and with minimum physico-chemical changes. Microbiological count was observed on 6 months storage and increased with increase in storage temperature (Aruna *et al.*, 1999).

Organoleptic qualities of Papaya leather (C0-2 variety) and Papaya-Mango blended leather (60-40) were evaluated in comparison with plain Mango leather. The results on sensory parameters indicated that blended leather was superior in most of the quality attributes. Storage upto eight months could be possible with Papaya-Mango blended leather and there was no evidence of microbial contamination (Cherian and Cheriyan, 2003).

2.7.1.5 *Bael slab*

It is also known as leather or papar. Ripe Bael fruits are used in its preparations. Wash ripe fruits and collect fruit pulp by breaking fruit and removing its hard shell. Add 200 to 300 ml of water for each 1 kg of fruit pulp, mix well and heat it upto 80°C. Collect fruit pulp free of seeds and fibers by straining heated mass through stainless steel sieve. Add sugar, citric acid and potassium meta-bisulphite (KMS) to this pulp so that treated pulp contains 35 per cent total soluble solids, 0.5 percent total acidity and 0.07 percent KMS. Boil treated pulp and spread on aluminium trays smeared with butter. Dry at 55 to 60°C for 15-16 hour to moisture content of 14.5 percent. Cut slabs of dried pulp in aluminum trays, warp in butter Paper and pack in polyethylene bags (Rakesh *et al.*, 2005).

2.7.1.6 *Blended fruit bar*

Gayathri and Uthira (2008) prepared protein enriched Mango and Papaya blended fruit bars in two different proportions i.e. 75:25 (Std-I) and 50:50 (Std-II) enriched with different levels of whey protein concentrate (WPC-70) like 5, 7 and 10 per cent was prepared and these were considered as experimental bars. Among the different combinations of experimental fruit bars, Mango-Papaya pulp in the ratio of 3:1 with 5 and 7 per cent WPC had good sensory scores. The fruit bars with equal amount of Mango and Papaya pulp, the experimental bars were different significantly in quality from the standard. The protein content of the standard fruit bar (75:25) was 0.62g per cent whereas experimental bars with 5 and 7 per cent WPC had a protein of 3.45 and 4.57 g per cent respectively.

2.7.1.7 *Textural properties of bar*

Retexturised fruit bars were prepared by using Banana (*Musa paradisiaca* L.), Mango (*Magnifera indica* L.) and Papaya (*Carica Papaya* L.) fruit pulps. The fruit

pulp extracted by cold extraction method was passed through ASTM 20 mesh sieve and pasteurized (at the temperature of 60°C for Banana pulp, 85°C for Mango pulp and 88°C for Papaya pulp) for 3min. The potassium metabisulphite was added as a preservative. The retexturised fruit bars were prepared by incorporating dehulled bengal gram blended maize extrudates in order to modify its texture. The firmness value is more for Papaya pulp followed by Mango and Banana pulp and cohesiveness and resistance to flow values also follows the same pattern. But the consistency value shows a slightly higher value was more for Mango followed by Papaya and Banana pulp. For puncture test, firmness value more for retexturised fruit bar made out of Papaya pulp rather Banana and Mango. The stickiness of retexturized fruit bar made out of Banana pulp is higher in comparison with retexturized fruit bar made out of Mango and Papaya pulp. The firmness value increases to eight to ten folds, because of transformation of fruit pulps to their respective retexturised fruit bars. The firmness of retexturised fruit bar is found to be ten times more than its corresponding fruit pulp (Balasubramanian, 2007).

2.7.2 Beverages

Fruit beverages are becoming increasingly popular in comparison to the synthetic drinks evidently, because of their taste, flavour and nutritive value. There has been considerable increase at consumption of fruit and vegetable juice beverages in the world during the last few years. Contrary to this, the fruit juice industry in our country is still not on sound footing. Like in many countries, fruit juice beverages are not an integral part of the typical Indian diet. Fruit juice beverages are considered more as occasional drink in our country. Bottled squashes, nectars and other fruit based beverages are looked upon as expensive indulgence. The consumer compares the cost of such items directly with the cost incurred in making juice at home when fruit is in season. In such a market, RTS fruit beverage containing 10-15% juice with low price can become a viable alternative to the bottled soft drink with different brand acceptable to the consumer. RTS is a type of fruit beverage, which should have at least 10 per cent juice, 10 per cent TSS and desirable amount of acid. The acidity of fresh juice/pulp plays an important role in the preparation of beverage. The acidity varies from fruit to fruit, its composition depends on its maturity.

Jain and Broker (1970) prepared RTS from Guava fruit with high pulp content and noticed that acid greatly improved the flavour. The RTS of composition of 10 per cent pulp, 15 per cent TSS and 0.3 per cent acidity was found ideal for Guava fruit (Singh *et al.,* 1983). Tiwari and Dinesh (2001) prepared RTS from Guava fruit with 15 per cent pulp, 18 per cent TSS and 0.3 per cent acidity.

Pruthi (1978) reported that RTS beverage can be prepared from kinnow mandarin by keeping the level of juice at 10 per cent and by adding suitable quantity of sugar, citric acid and water to raise total soluble solids to 13-15 per cent, and total acidity to 0.3 to 0.4 per cent. He suggested that beverage could be prepared and preserved by pasteurization in bottle or by adding sulphur dioxide (70 ppm). RTS with composition of 10 per cent, 15 per cent total soluble solids and 0.3 per cent total acidity was found to be ideal for rangpur Lime (Singh and Pathak, 1983) and mandarin Orange (Singh, 1983). Saini *et al.* (1982) described the technology for preparation of RTS from Mango fruits and 15 per cent pulp, 13 per cent TSS and 0.3 per cent acidity was found as an ideal recipe. Kotecha *et al.* (1995) found that 20 per cent pulp, 15 per cent TSS and 0.25 per cent acidity was ideal recipe for custard Apple RTS. Prashad *et al.* (1968) reported that squash and ready to drink beverage prepared from Aonla juice were palatable and satisfactory.

2.7.2.1 ***Wood Apple nectar***

Fruits are deshelled by hand and the pulp with seeds were mixed with required quantity of water and boiled twice, for two extractions from pulp. TSS was raised to 13°Brix by addition of sugar from its original 7°Brix. The prepared juice after boiling for 30 minutes was filled into cans, while it was still hot, by using stainless steel laddle. Then the cans were sealed by a hand machine and sterilized in boiling water bath for 30 minutes cooled and storage was done at room temperature. Wood Apple has protein content of 7.1g, fat 2.1g, mineral 1.99 and 134 calories per 100g of edible portion (FAO, 1973).

Swamy *et al.*, (1977) studied utilization of unconventional fruits for the preparation of ready-to-drink beverages included the unconventional fruits such as Wood Apple, Chakota, Cashew Apple, Kamardrakshi, Hebbalsu, Punarpuli, Jamnerale, Yelachi and Passion fruits were selected for the preparation of beverage.

Artificial colours and flavours were added for selected fruit juices for enhanced acceptability. Eighty-nine samples were tested for beverage value by sensory evaluation. Results of the data showed that Cashew Apple, Passion fruit, Hebbalsu, Kobrikayi, Yelachi, Punarpali pulp and Wood Apple juices were scored desirable with and without artificial flavouring agents among the total number of juice studied. Cardamom flavours were most frequently liked as artificial flavours with juices. Study indicated many of the little known fruit could yield every desirable fruit juices. Cultivation and protection of these are desirable. A few of the artificial colours and flavour could add interest and variety to the consumer.

2.7.2.2 *Guava nectar*

Guava (*Psidium guajava* L.) is an important tropical fruit because of its unique flavour and nutritive properties. It is consumed fresh, or as raw material for Guava nectar, which is turbid and viscous. Processing consists of crushing and finishing with a paddle finisher equipped with screen to remove seeds, skin and stone cells (Luh, 1980) to produce a puree. Puree is then diluted with water, sugar and citric acid and stabilizers are added. It is then pasteurized to yield Guava nectar. A stabilizer, such as carbo-methyl cellulose (CMC) is added to prevent early sedimentation of the suspended solids during storage.

A possible alternative to the turbid Guava nectar is a clarified product. The materials that cause turbidity and subsequent precipitation during storage are polysaccharides (e.g. pectin and starch), proteins, polyphenols, multi-valent metal ions and lipid (Heatherbell, 1984). These substances can be removed by physical methods e.g. sedimentation, centrifugation and filtration; biochemical methods, primarily enzymic hydrolysis or by chemical fining. High speed centrifugation would clarify the nectar but might not be economically feasible (Heatherbell, 1984). Sedimentation is usually used with pectic enzymes or fining agents and membrane filtration is now widely used commercially to clarify Apple juice. Ultrafiltration has been applied successfully to clarify Pear (Kirk *et al.*, 1983) Kiwi fruit (Wilson and Burns, 1983) and Alfalfa juice (Knuckles *et al.*, 1980).

Chan and Chiang (1992) evaluated three fining method for use in producing clarified Guava nectar. the enzyme hydrolysis method, especially treating the Guava

puree with 1000 ppm of Pectinase at 50°C for 3 hour, accomplished satisfactory clarification but caused severe losses in volatile components, pre-treating the puree with 100 ppm of Pectinase for 1 hr. greatly facilitated the subsequent bentonite or ultrafilteration clarification processes, and both the bentonite treatment and the ultrafilteration process yielded clarified product, but the ultrafiltered product had less loss of volatiles. However, to achieve storage stability, a membrane of lower than 100,000 dalton molecular weight cut-off should be used. Guava is one of the rich sources of ascorbic acid. The fruit utilized for processing into different products as well as for table purpose. Guava juice and beverages have been studied by Nanjundaswamy *et al.* (1964) and Jain and Barker, (1966, 70). Khurdiya and Sagar (1991) investigated that grittiness in Guava beverages is a serous problem. This might be due to the presence of stone cells of the fruit. They removed the grittiness and improved the organoleptic quality of the Guava nectar. Pectic enzymes, particularly pectinesterase (PE) and polygalacturonase (PG), modify the pectic substances surrounding the suspended particles in the juice to expose the dissimilarly charged surfaces and produce flocculation due to electrostatic attraction (Kilara, 1982). The flocs can be removed by sedimentation or filtration to yield a clarified juice. Pectinase has also been added to Guava puree to increase the clarification and yield of the juice (Imungi *et al.*, 1980; Sandhu and Bhatia, 1985).

The fining agents most often used to clarify juice are gelatin and bentonite (Amerine *et al.*, 1976). Geltin is positively charged under the acidic condition of fruit juices and interacts with the negatively charged pectin and results in precipitation (Van Buren and Robinson, 1969). Bentonite, which is negatively charged, attracts the positively charged proteins and removes them from the juices (Kean and Marsh, 1956). Other fining agents, such as tannin, casein, silica gel, and egg albumin may also have some effect on clarifying fruit juices, but are seldom used.

The pulp was converted into nectar having 20% pulp, 15°Brix TSS and 0.26 percent acidity. The nectar was heated to 90°C and filled at that temperature into clean and sterilized glass bottles (200 ml capacity) crown corked immediately and cooled in the air. The bottle nectar was stored at room temperature (16.34^0C).

2.7.2.3 *Mango nectar*

Mango produces wide spectrum of fruit products. Chakraborthy *et al.* (1991) studied varietal screening of Mangoes of Uttar Pradesh for their suitability for production of canned nectar juice and pulp. They included nine varieties of Mangoes viz. Dasheri, Chausa, Safeda, Tamburia Dasheri, Mala fazli, Lucknow fazli, Mallika, Bhagwankera and Golbhadiya grown in U.P. region. The pulp was extracted from fully ripe fruits canned and used for preparing canned nectar and juice. The canned samples were stored at ambient conditions (20-42°C) for about 4-6 months and analysed for their important physico-chemical and sensory qualities. Canned nectar and juice samples prepared from seven commercial varieties of Mangoes were ranked for color, aroma, taste and overall acceptability with respect to reference Badami Mangoes. Based on the overall acceptability Dasheri, Tamburia Dasheri found to be good and comparable to Badami (Alphonso) for preparing canned Mango nectar and juice (significantly superior at $p < 0.01$) Malda fazali, Lucknow Fazali, Chausa and Golbhadiya were next preferable (significant at <0.05) nectar and juice made from Safedia and Lucknow Fazli were found significantly inferior.

2.7.2.4 *Papaya nectar*

Papaya contains pectin that helps in proper pulp distribution in the juice. Papaya has natural colour and flavour and hence requires no artificial flavouring and colouring. Nectar was prepared from Papaya and less deterioration changes were observed on storage for nine months. Nectar was acceptable even after nine months storage. Chilled nectar was preferred by the panel members. The non-enzymatic browning gradually increased on storage. The vitamins of the beverage decreased drastically on storage (Aruna *et al.*, 1997).

2.7.2.5 *Phalsa nectar*

Waskar and Khurdiya (1987) worked on processing and storage of 'Phalsa' beverage and evaluated that the attractive color of perishable 'Phalsa' fruit and its beverage is due to anthocyanins which is liable to quick degradation at high temperatures prevailing during harvesting season and storage of beverage. The investigation was undertaken to study the processing and storage of Phalsa beverages such as nectar, concentrate, squash and crush. It was found that there was a maximum retention of anthocyanins in the Phalsa beverage stored in cool store followed by

storage in cool chamber and at room temperature. All these beverages were found to be acceptable upto 180 days and crush to 240 days in cool store followed by 120 days in cool chamber but upto 60 days at room temperature.

2.7.2.6 *Beal fruit nectar*

The nutritive value of fruit beverage is far greater than that of synthetic products, which are at present being bottled and sold in large quality throughout the country. If fruit pulp/juice could be substitute for these synthetic preparations, it would be a boon to the consumers as well as to fruit growers. Thus, there is a great scope in the country for fruit based beverages. The processing techniques of Bael beverages i.e. RTS drink, nectar, squash and syrup are explained by Rakesh *et al.* (2007).

In Bael nectar, natural composition of fruit pulp is changed by addition of requisite amount of sugar, citric acid and water. According to fruit products orders, this type of fruit beverage should contain at least 20% fruit pulp/juice, 15% total soluble solids and about 0.3% acidity. It is not diluted before serving.

2.7.3 Blended Beverage

Recently, food processing industry in India exhibited a bright outlook with an estimated 0.57 million tonnes of fruits and vegetable products valued at 2.5 billion rupees. According to another estimate, the industrial units in India have acquired capacity to produce 700 million units of fruit based beverage of 200 ml of tetrapacks type (Anonymous, 1988). Mango products share about 50 percent of total fruit products while in beverage the proportion is even more. The aseptic system has given a big boost of the fruit beverage industry.

The blending of fruit drinks could be an economic requisite to utilize profitably some fruit varieties for processing. Kalra *et al.* (1991) prepared Mango-Papaya blended beverage and preserved for one year in glass bottles under ambient conditions (20-36°C). Titrable acidity and TSS did not change significantly during storage. The Papaya beverage (15% pulp) contained double the contents of vitamin C (8 mg per cent) as compared to pure Mango beverage and its preservation was about 80 per cent after one year storage. The yellowness index (YI) of Mango was higher

than Papaya. The organoleptic acceptability declined in Dashehari but otherwise it was good even after 12 months storage. They indicated that 25-33 per cent Papaya pulp could be incorporated in Mango without affecting the quality and acceptability of the Mango beverage.

Various workers (Tripathi *et al.*, 1992; Attri *et al.*, 1998) have reported that two or more fruit juices/pulp may be blended in various proportions for the preparation of more palatable and nutritious nectars, RTS beverages, etc. Moreover there is always a demand of consumers all over the world for new food products, which should be nutritious and delicately flavoured.

The quality of the RTS beverage could be improved by blending of different fruit juice/pulp (Mango, Lime, Aonla, Grape, Pineapple) in appropriate proportions. Pederson *et al.* (1941) reported that the Apple-raspberry was extremely delicious, which contained 25 per cent raspberry and 75 per cent Apple juice. Beattie and Pederson (1941) recommended the use of frozen cherries for making of cherry-Apple juice blend with a ratio of 55 parts of Cherry to 45 parts of Apple.

Attri *et al.* (1998) studied the effect of blending of sand pear juice with Apple juice concentrate, Apricot pulp and Plum in different ratios. Shukla *et al.* (2005) developed a delicious, nutritious and cheaper drink / beverage by blending Apple juice at 4 different levels i.e. 10, 20, 30 and 40 per cent with whey. The beverage with Apple juice level of 20 per cent in whey was liked the most.

Begum *et al.* (1983) have tried Pineapple and Mango pulp mixture in the ratio of 25:75, 55:50 and 75:25 for squash and they have claimed good consumer acceptance. Blending of two or more than two fruits was studied for preparation of ready-to-serve (RTS) beverage to improve colour, flavour and over all acceptability of a drink.

2.7.3.1 ***Cocktail***

Swamy *et al.* (1977) worked on Utilization of unconventional fruits for the preparation of ready-to-drink punch. Cultivation of new fruits, production of fruit beverages from many of the non-table fruits could bring benefit nutritionally and

economically. Ten varieties of semi-wild and wild fruits were used in the preparation of 62 selected types of fruit punches. Five different fruit drinks were prepared for each type of punch and mixed in equal volumes. Sensory evaluation was conducted to evaluate all the fruit punches for appearance, flavour, consistency and overall acceptability. Data collected were statistically analysed to arrive at those punches which were scored highest to lowest of the scale and to test how much of these characteristics have influence on the overall acceptability is explained to the extent of 91.5 per cent. Commercial production of these punches is desirable as these fruits are cheaper and nutritious too.

Fruit cocktail mixes have been familiar to India as the word 'punch' itself comes from Sanskrit, meaning 'five', and American dictionary says as combination of five fruits with flavour and mild alcoholic content. Beverages contribute greatly to quench the thirst of man in tropical countries through it could greatly add to the nutrition of his total dietary takes if regularly taken as a part of meal, which is hardly practiced in India (Agkroyd, 1970).

2.7.4 Carbonated Drink

Thorat *et al.* (2007) prepared carbonated beverage with 10 per cent Aonla juice and 1.2 per cent Ginger juice. The protocol standardization was alone by evaluating three factors i.e. Aonla juice extraction methods (hot and cold methods), packaging materials like glass and pet bottles and aloe juice levels of 0, 1 and 2 percent. The total soluble solids contents of the carbonated beverage were initially maintained to 12.8°Brix. Cold method of juice extrication was found to be superior for the beverage for the fresh consumption, however, for storage, beverage prepared from Aonla juice extracted by hot method is superior. Aloe vera juice increased the quality of carbonated beverage by increasing stability of biochemical parameters. The highest level of aloe juice (2%) content in the beverage recorded the best results. Among the treatments, carbonated beverage prepared from Aonla juice extracted by hot extraction method blended with 2 per cent. Aloe juice and stored in glass bottle ($E_1P_1A_2$) at cold storage recorded minimum increased in TSS, total sugars, reducing sugars, non-reducing sugars, pH and retained the maximum acidity and ascorbic acid content at both the storage conditions. The same treatment recorded the minimum microbial count ($6x10^3$cfu/ml) after 90 days, thus having the best consumer

preference in terms of overall acceptability. Long term storage of the Aonla based carbonated beverage in the acceptable form can be achieved by adopting glass bottle packaging and storing the beverage under cold conditions.

2.7.4.1 *Preparation of carbonated drink*

Phalsa and Jamun juice were converted into drinks of different Brix, acid ratios, containing variable percentage of juice. The drinks were chilled (3-5°C) and subject to 40-60 and 80 psi of carbon dioxide (CO_2) gas pressure, and filled into clean, sterilized glass bottle (200ml capacity). Sealed immediately with crown cork.

The Lime juice of both the methods was converted into a drink of 10°Brix and 0.2 percent acidity gas pressure in a carbonated at 100 psi CO_2 gas pressure in a carbonating unit after Chilling (3-5°C) and sealed immediately with crown cork. Khuriya *et al.* (1997) produced successfully carbonated beverage from Phalsa, Lime and Grape juice and their Pomace extract. After juice extraction fruit Pomace possessed valuable soluble solids, acid, anthocyanin, tannin and ascorbic acid, which can be extracted with water in Pomace extract. The carbonated beverage made from the juice, Pomace extract and their combination did not show any significant difference with respect of color and flavor. Hence, Phalsa Lime and Grape Pomace can be utilized gainfully for the production of value added carbonated beverage.

Jadhav *et al.* (2002) standardized a suitable method for preparation of a carbonated beverage from tamarind juice and to study the changes in chemical composition and sensory properties during storage. It was found that the carbonated beverage stored at cold temperature showed maximum storability of 35 days with out affecting taste and flavor.

2.7.5 Powder

2.7.5.1 *Bael powder*

Bael (*Aegle marmelos* Cornea) is one of the most nutritious fruits rich in vitamins and minerals and has medicinal value. It lacks popularity as a table fruits due to its hard shell, excessive mucilage and large number of seeds, but has great potential for processing. Bael fruit powder is prepared by some of the pharmaceutical companies, but the information regarding the suitability of a clone with a suitable

method of drying for the preparation Bael fruit powder is lacking. Bael powder can be prepared by simply grinding dried fruit slices in a grinder. Pack ground Bael powder in polyethylene bags and store in dry places after proper sealing for consumption in future (Rakesh *et al.*, 2005).

The fruit pulp was extracted from fully ripened fruits of each clone as per method of Roy and Singh (1979). The pulp was dried separately in the sun and cabinet drier (60±1°C) in uniform size of trays. Thus, there were 12 treatments combination (six clones x two methods of dryings) replicated thrice in two factor Randomized Block Design. The dried pulp was sieved through 30 mesh sieve to obtain uniform samples.

Roy and Singh (1979) found that Bael fruit powder was prepared by drying the pulp after adding 500, 1000, 1500 and 2000 ppm SO_2 in the form of a thin sheet to 10 per cent moisture, the sheets were cut into pieces and further dried to below 4 per cent moisture in a cabinet drier at 60±5°C. The pieces were ground into powder in a grinding machine as mentioned by Khurdiya and Roy (1974) in Guava. The Bael fruit powder was packed in 400 gauge polyethylene pouches and kept for storage studies.

2.7.5.2 *Mango powder*

Mango is the most popular tropical fruit and is very much relished for its succulence, exotic flavors and delicious taste throughout the world (Nanjundaswamy *et al.*, 1976). Apart from its delicacy it is a nutritionally important fruit since it is a very good source of beta-carotene. India ranks first in the world having share of 51% (FAO, 1997). Conventional type of Mango produces have been developed to a considerable extent, but the present need is to develop new processed products to utilize the Mangoes successfully and to minimize post harvest losses. Baldry *et al.* (1976), Najundaswamy (1984) and Jagatiani (1998) prepared ripe Mango powders using various procedures. These powders when consumed, beta-carotene is better absorbed due to the presence of milk fat (Jayaraman *et al.*, 1980; Erdman *et al.*, 1993) and also gives a pleasant yellow color when added to any food which avoids the necessity of adding any synthetic colours.

Hymavathi and Khader (2005) developed vacuum dehydrated ripe Mango powders from three varieties of Mangoes (Baneshan, Savarnarekha and Totapuri) and their blends. These powders were incorporated in selected recipes at 10 and 15% levels and found that the 15% level of incorporation was accepted well, by the sensory panel.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 PLAN OF WORK

Wood Apple, Mango, Ginger etc were procured from local market and adjoining villages. The present study was carried out in following stages.

(i) extraction of pulp from Wood Apple fruit

(ii) extraction of oleoresin

(iii) preparation of fruit juice from extracted pulp (with the help of Enzyme also)

(iv) development of fruit bar with combination of other fruit pulp (Mango, Papaya and Ginger).

(v) development of nectar

(vi) development of blended beverage drink by mixing Wood Apple pulp with Mango juice, Ginger juice and soft drink (Cola and Orange flavour).

(vii) development of carbonated drink of Wood Apple.

(viii) preparation of Wood Apple powder with Ginger and Aonla powder.

(ix) evaluation of quality and shelf life of developed product.

3.2 RAW MATERIAL

3.2.1 Wood Apple Pulp

Ripe 'Wood Apple' fruits, procured from local market and adjoing villages of Jhansi, were washed in running water to remove adhered dust, dirt and mucilaginous substances. Flesh was obtained by breaking the fruit shell and removing the peels. Flesh–water blends were prepared separately by manual mixing of flesh and water in 1:0.5, 1:1, 1:2 and 1:3 ratios in triplicates. Blends were heated at 100°C, cooled and passed through the muslin cloth. Chopra *et al.* (2001) studied the effect of dilution of Wood Apple flesh and thermal treatment of flesh – water blends on the ease of pulping, pulp yield and the chemical characteristics of the extracted pulp. Extraction was difficult when added water was less than one part of flesh. Dilution increased the pulp yield but lowered the content of TSS, acid and vitamin C in pulp. The ratio of flash and water in a ratio of 1:2 found it easy for extraction of pulp at 100°C. The flow diagram for the extraction of Wood Apple pulp is presented in Fig. 3.1.

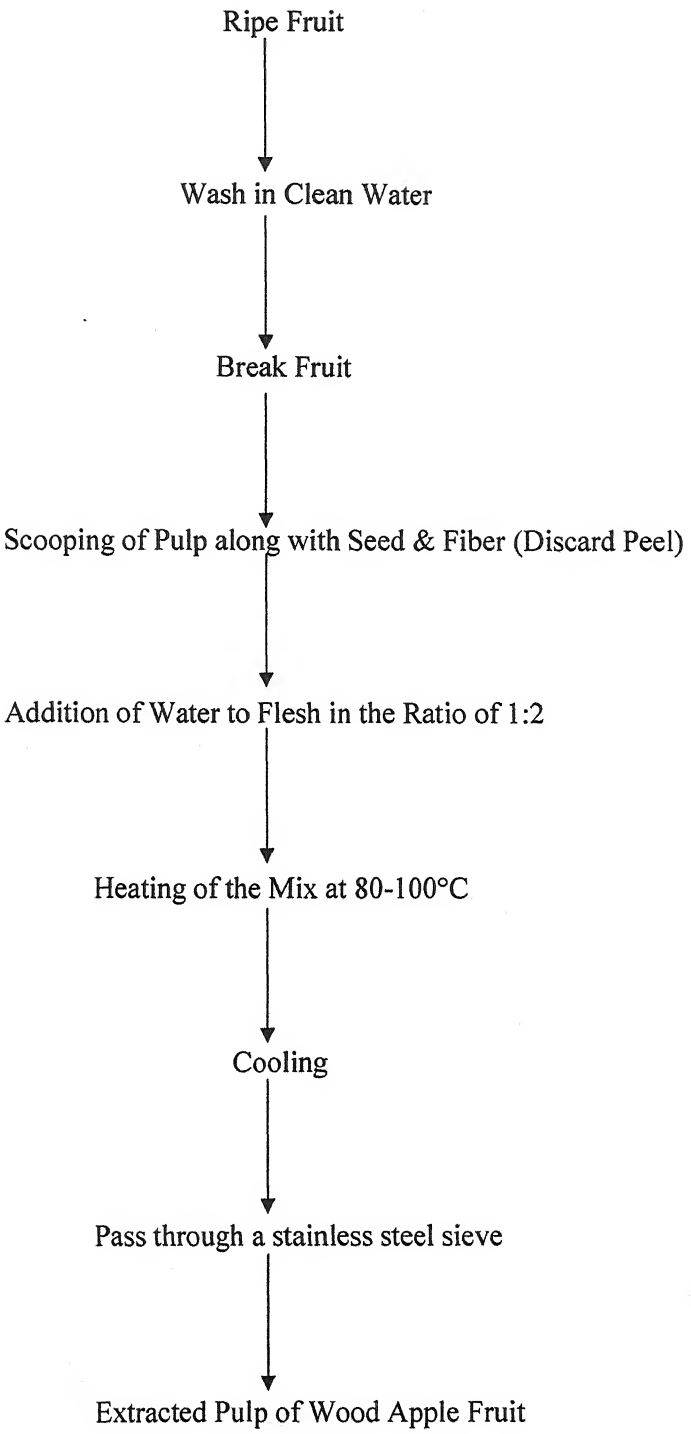


Fig. 3.1: Extraction of Wood Apple pulp

3.2.1.1 *Pulp treated with Enzyme for juice preparation*

Wood Apple pulp was treated with Enzyme (Tryzyme) in three different percentages 0.5, 1.0 and 1.5. No appreciable change was observed in the juice. The ordinary method of juice preparation was best than the enzyme treated method.

3.2.2 Mango

Mango was purchased from local fruit market, washed thoroughly and pulp was extracted manually.

3.2.3 Ginger Pulp

Ginger was procured from local market, washed with running water. Pulp was prepared manually.

3.2.4 Other Ingredients

- Sugar was procured from the local market of Jhansi.
- Commercial food grade citric acid supplied by Central Drug House (P) Ltd. was used as acidulants.
- Potassium metabisulphite used as a preservative.
- Aonla powder and Ginger powder were purchased from local market.

3.2.5 Oleoresin Extraction

The shell and pulp were separated by breaking the fruit and scraping the inside part of the shell. The seeds were recovered by agitating the fruit pulp repeatedly with hot water and straining the aqueous suspension through filter cloth. The wet seed was dried in the sun, and also by hot air in an air oven. The seed was ground and oleoresin was extracted by solvent extraction method with the help of hexane.

3.3 PRODUCT DEVELOPMENT

3.3.1 Development of Wood Apple Fruit Bar (Control)

3.3.1.1 *Optimization of sugar percentage*

Extracted Wood Apple pulp (6°Brix) was heated at 80°C for 10-15 minutes. Sugar was added in three different percentages 20, 30 and 40 percent (Table 3.1).

3.3.2 Development of Wood Apple Mango Bar

3.3.2.1 *Optimization of Mango pulp level*

Mango pulp (13°Brix) was mixed with Wood Apple pulp in four percentages 10, 30, 50 and 70 percent (Table 3.2). Wood Apple pulp and Mango pulp were blended properly and heated for 10-15 minutes. At this stage, sugar (30 per cent) was added and heated at 80°C for dissolving the sugar. Heating is continued upto desired consistency and pulp was spread on the tray and dried in the oven at 65-70°C for 24 hr. After cooling pieces were cut and packaged into aluminium foil and polythene. Sensory quality of fruit bar was evaluated.

3.3.3 Development of Wood Apple Papaya Bar

3.3.3.1 *Optimization of Papaya pulp level*

In the preparation of Wood Apple Papaya bar, Papaya pulp was mixed in three different percentages 10, 30 and 50 percent (Table 3.3). It was processed in similar way as described in Sec 3.3.2.1.

3.3.4 Development of Wood Apple Ginger Bar

3.3.4.1 *Optimization of Ginger pulp level*

Ginger pulp (2°Brix) was mixed with Wood Apple pulp in four different percentages of 3, 5, 10 and 15 percent (Table 3.4). Pulp was blended properly and processed in similar way as described in Sec 3.3.2.1.

3.3.5 Method of Preparation

Extracted Wood Apple pulp (6°Brix) was heated for 10-15 minutes. Heating is continued with co current stirring and scraping with the help of a scraper to avoid the burning till desired (pasty) consistency was obtained. The TSS of the blended pulp was raised to 30°Brix by adding standardized amount of sugar (30 percent) to the pulp. The temperature of the product was quickly raised to 80-90°C to dissolve sugar with continuous heating. Heating is continued with co current stirring and scraping with the help of a scraper to avoid the burning till desired (pasty) consistency was obtained and when most of the water gets evaporated. The product became thick in consistency and turned dark brown in colour. The whole mass was poured in tray and dried in the oven at 65-70°C for 24 hr, allowed to cool and cutted into smaller pieces of uniform sizes. These pieces were packaged into aluminium foil and polythene and

stored at room temperature (16-35°C). The flow diagram for the preparation of Wood Apple fruit bar is presented in Fig. 3.2.

3.3.6 Development of Wood Apple Nectar

3.3.6.1 *Optimization of pulp level*

Wood Apple pulp was added to water @ 20, 25 and 30 per cent.

3.3.6.2 *Optimization of sugar level*

Four percentages (5, 10, 15 and 20 percent) of sugar were used in Wood Apple nectar. The level of sugar was optimized on the basis of sweetness and desired TSS in the finished product. Sensory quality of nectar was evaluated.

3.3.6.3 *Optimization of citric acid*

Citric acid was mixed in four different percentages (0.15, 0.25, 0.50 and 1.0 percent).

3.3.6.4 *Optimization of KMS preservative*

Three types of percentage (0.01, 0.03 and 0.05 percent) were used in the nectar preparation.

3.3.7 Method of Preparation

Wood Apple juice was prepared by mixing the Wood Apple pulp (20 per cent) with water, homogenized and heated slightly. The sugar syrup was prepared separately and standardized amount of citric acid (0.03 percent) was added into it. After cooling of sugar syrup, Wood Apple juice mixed was into it and allowed to heat at 90-95°C, filled into sterilized bottles, crown corked, cooled and stored at refrigeration temperature (2-5°C). The flow diagram for the preparation of Wood Apple nectar is presented in Fig. 3.3.

3.3.8 Development of Blended Beverage (cocktail)

3.3.8.1 *Optimization of pulp level*

In the preparation of blended beverage, percentage of ginger pulp was standardized. Standardized percentage of ginger pulp (5 per cent) was mixed with wood apple pulp and mango pulp in the ratios of 60:35:5, 70:25:5, 80:15:5 and 90:5:5.

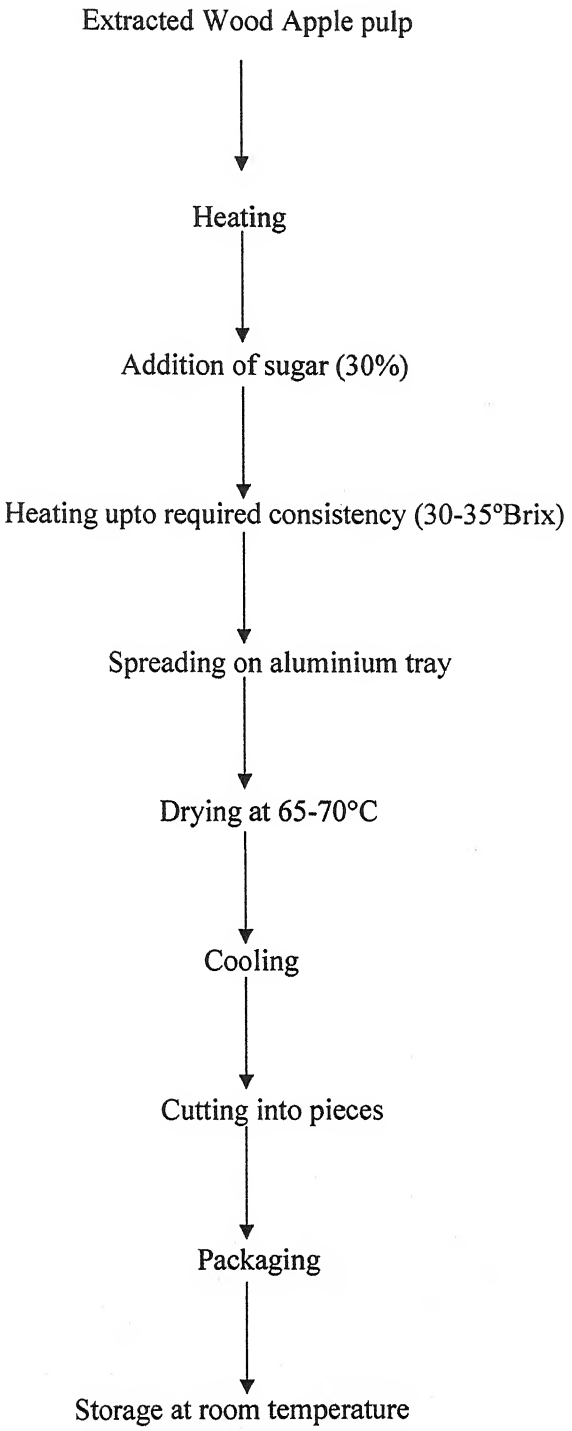
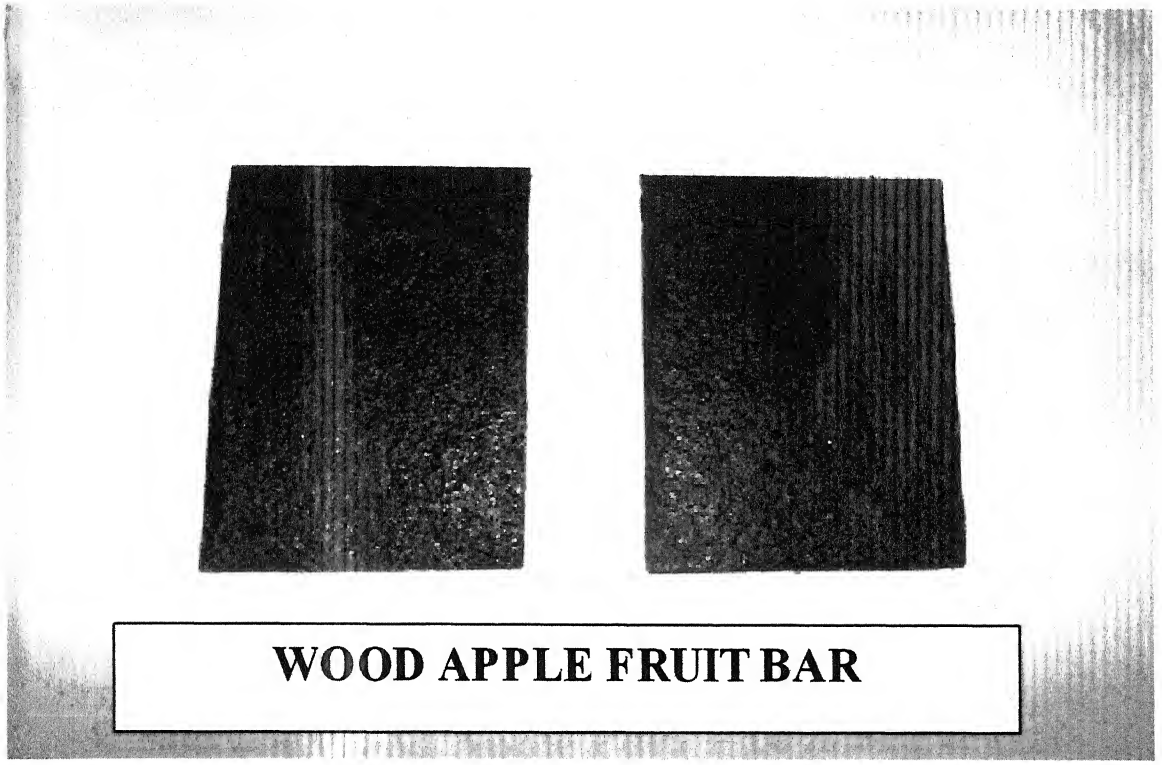
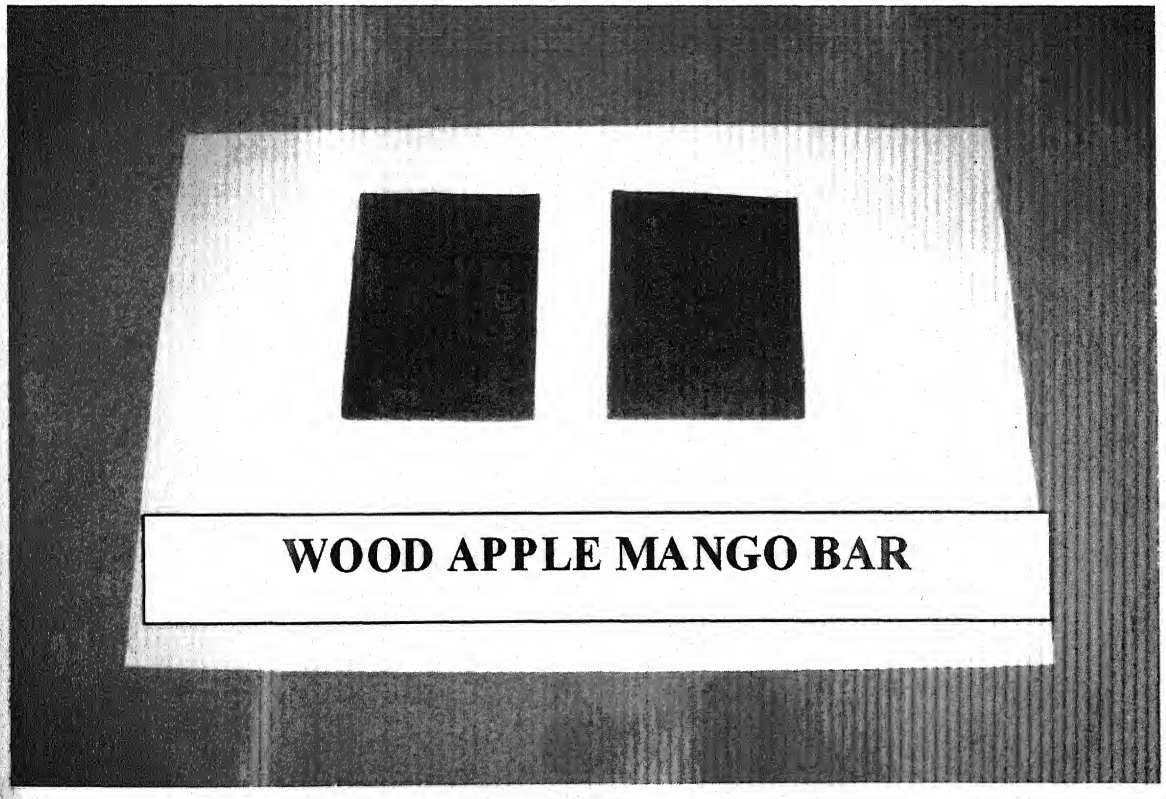


Fig. 3.2: Preparation of Wood Apple fruit bar



WOOD APPLE FRUIT BAR



WOOD APPLE MANGO BAR

PLATE-1

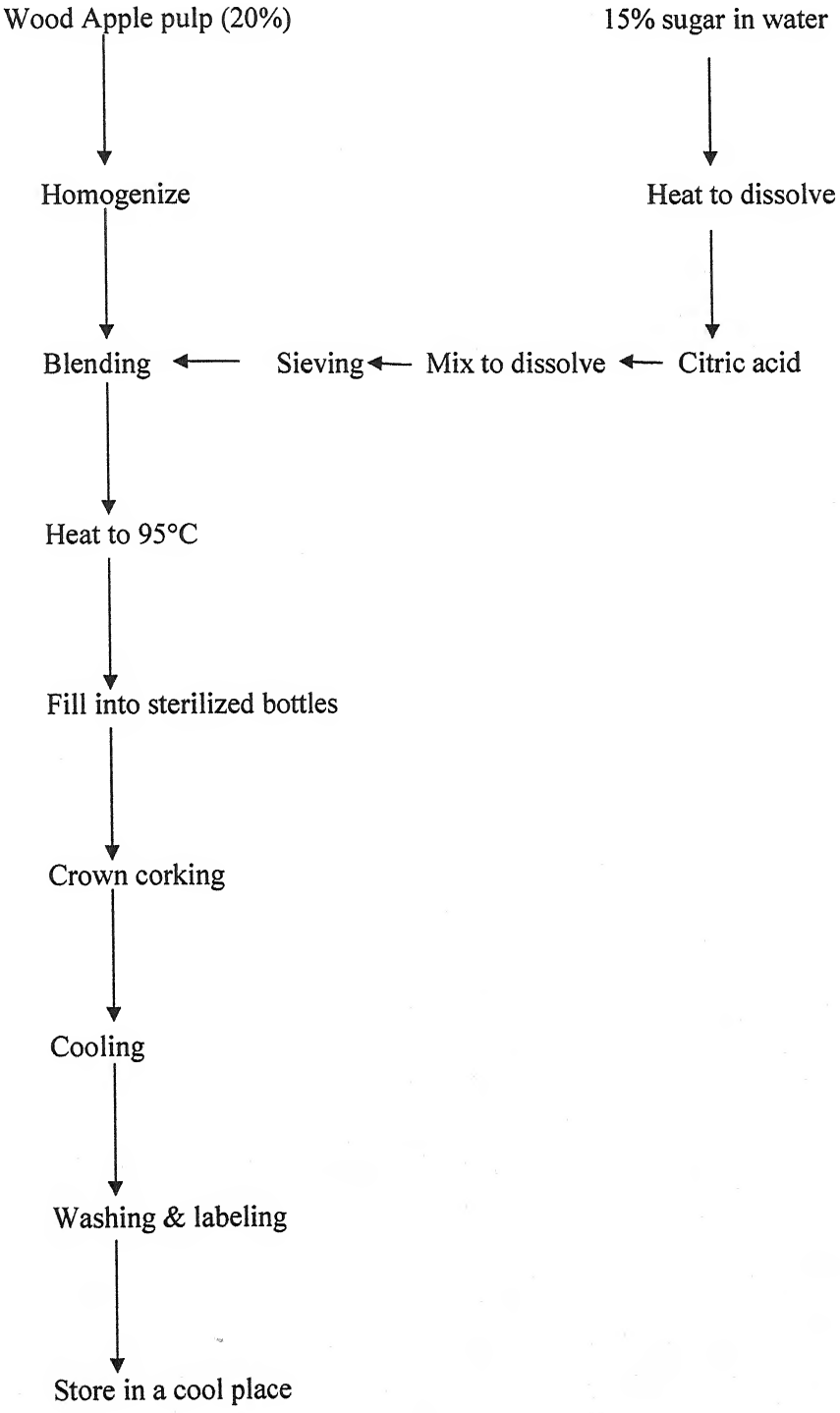
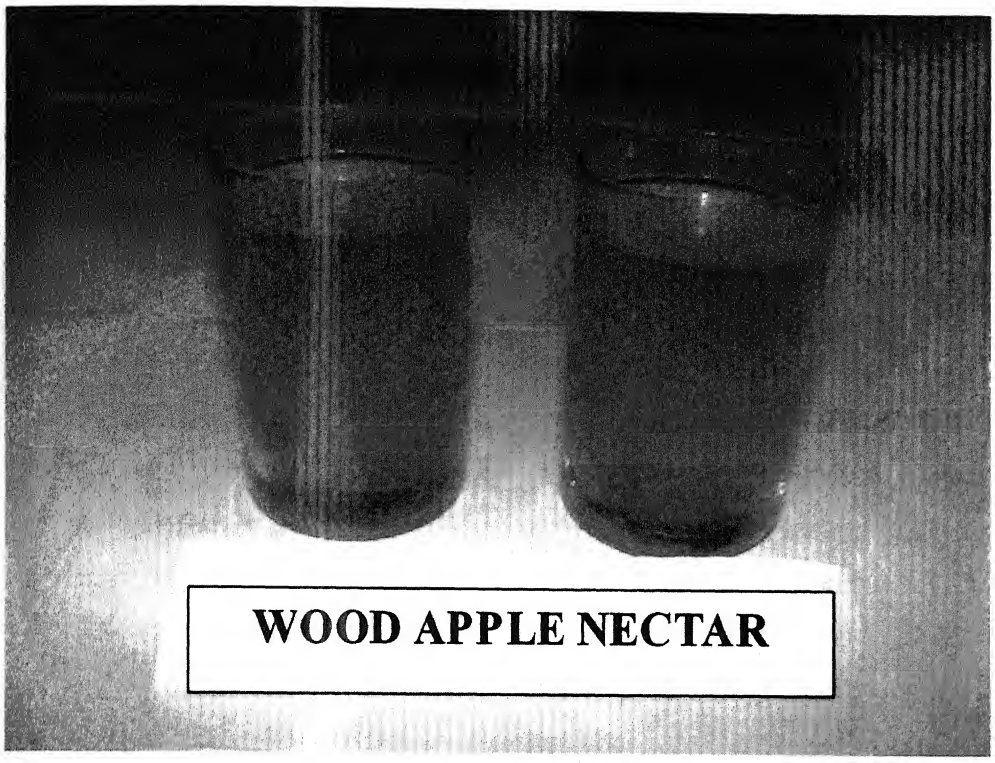
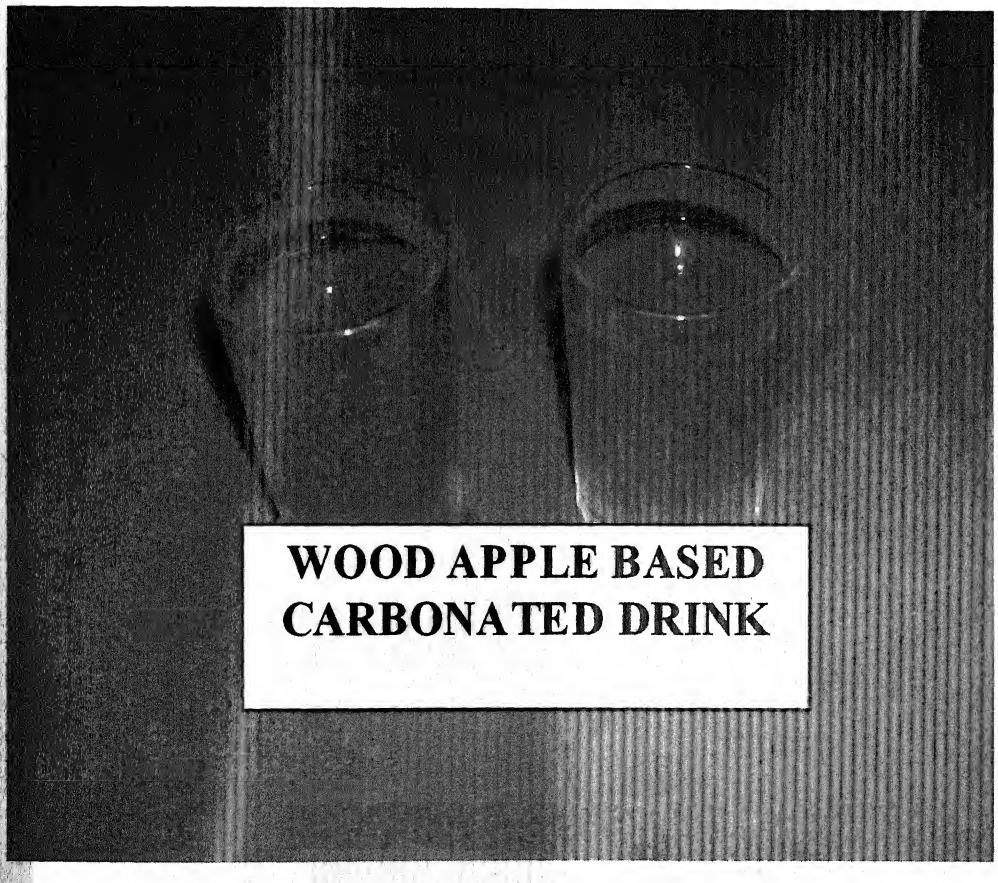


Fig. 3.3: Preparation of Wood Apple nectar



WOOD APPLE NECTAR



WOOD APPLE BASED CARBONATED DRINK

PLATE-2

3.3.8.2 *Optimization of sugar level*

Three percentages (10, 15 and 20 percent) of sugar were used in Wood Apple blended beverage. The level of sugar was optimized on the basis of sweetness and desired TSS in the finished product. Sensory quality of blended beverage was evaluated.

3.3.8.3 *Optimization of citric acid*

Citric acid was mixed in four different percentages (0.15, 0.25, 0.50 and 1.0 percent).

3.3.8.4 *Optimization of flavour*

Two types of flavour were used (cola and orange flavour). Flavour was mixed in the blended beverage after heating. In the process of blended beverage, after cooling, flavour was added and processed in similar way as described in Sec 3.3.6. The acceptability for flavour of blended beverage was finalized by panel members.

3.3.9 Method of Preparation

Standardized ratio of pulp was homogenized and mixed with water, heated and sieved. Sugar syrup was prepared by using standardized amount of sugar (15%). Sugar syrup was blended with mix juice, again sieved and allowed to heating, filled into sterilized bottles, crown corked, cooled, washed, labeled and stored at refrigeration temperature (2-5°C). Sensory quality of Wood Apple blended beverage was evaluated. The flow diagram for the preparation of Wood Apple blended beverage is presented in Fig. 3.4.

3.3.10 Development of Wood Apple based Carbonated Drink

3.3.10.1 *Optimization of Wood Apple pulp level*

Wood Apple pulp was added to water @ 20, 25 and 30 per cent.

3.3.10.2 *Optimization of sugar level*

Three percentages (10, 15 and 20 percent) of sugar were used in Wood Apple carbonated drink. The level of sugar was optimized on the basis of sweetness and desired TSS in the finished product. Sensory quality of carbonated drink was evaluated.

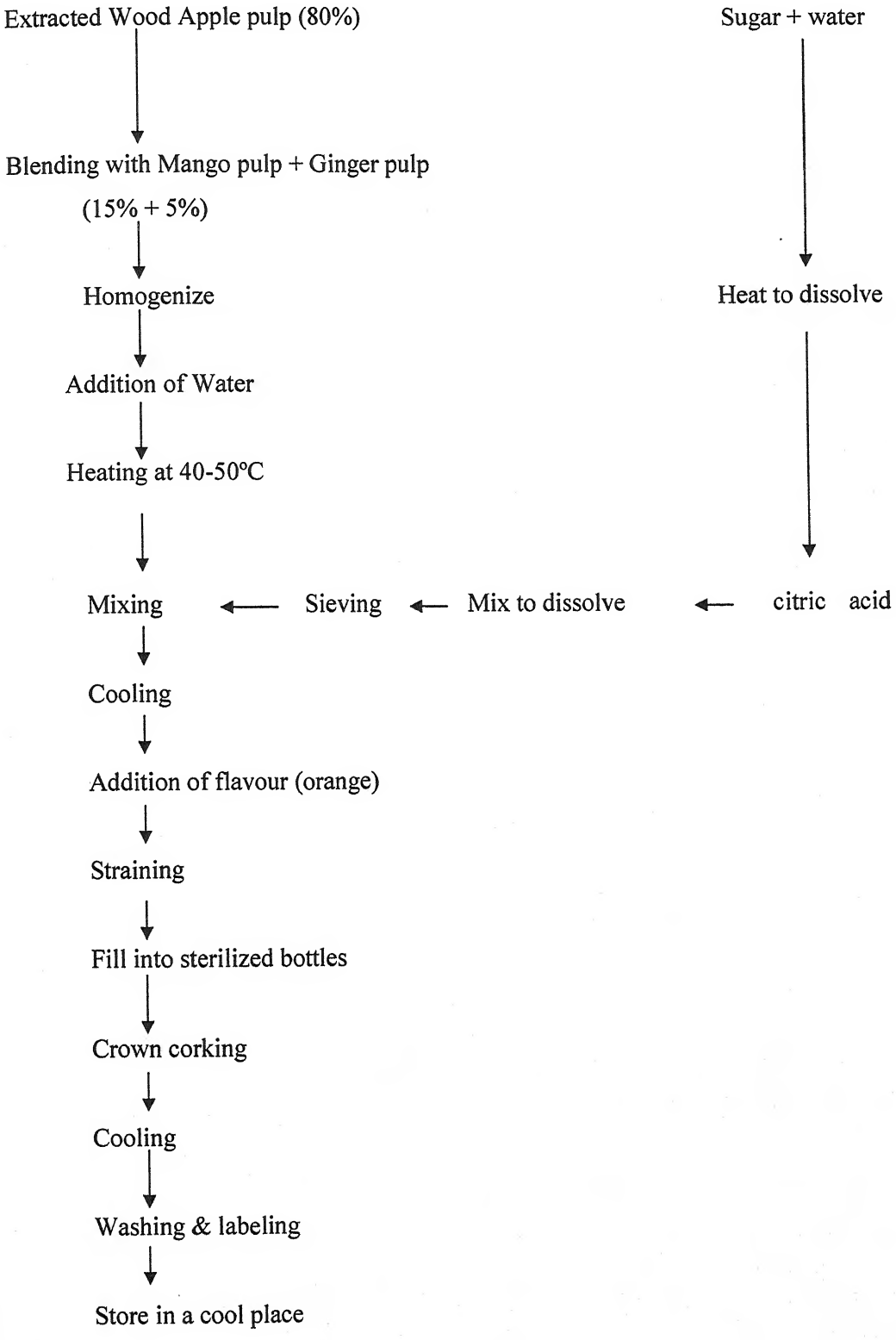
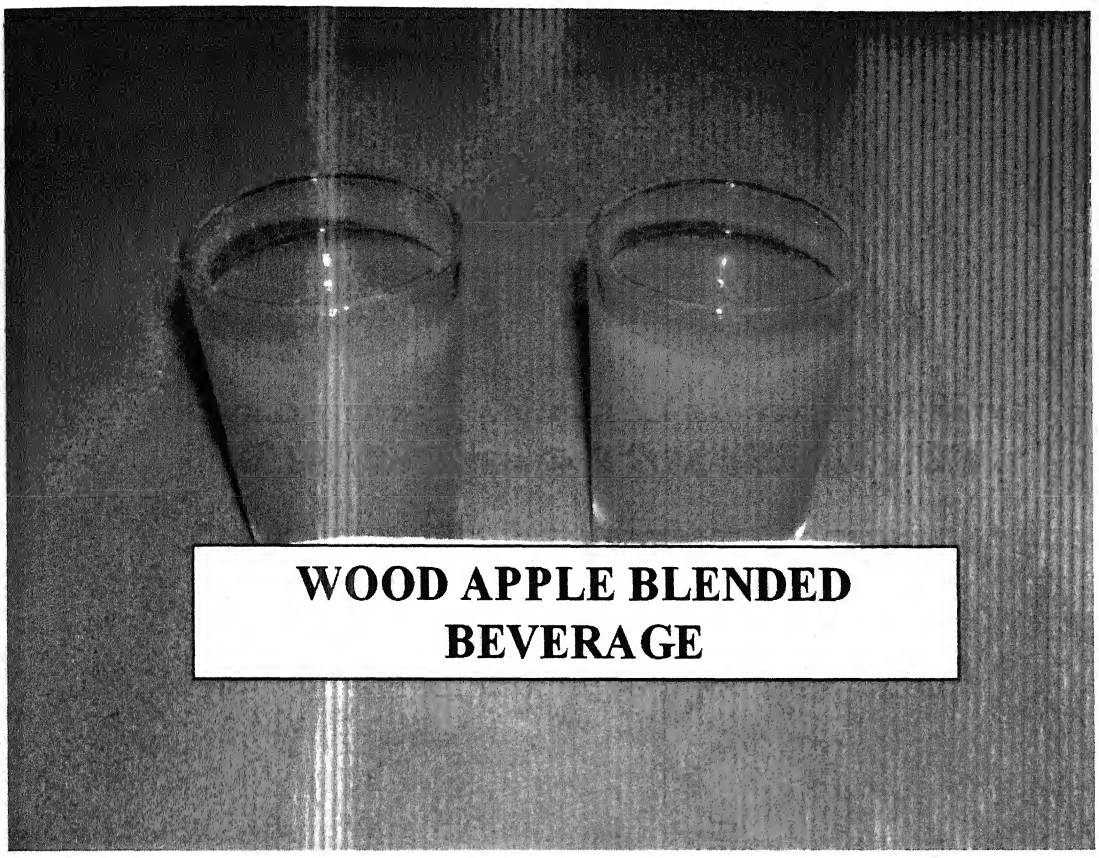
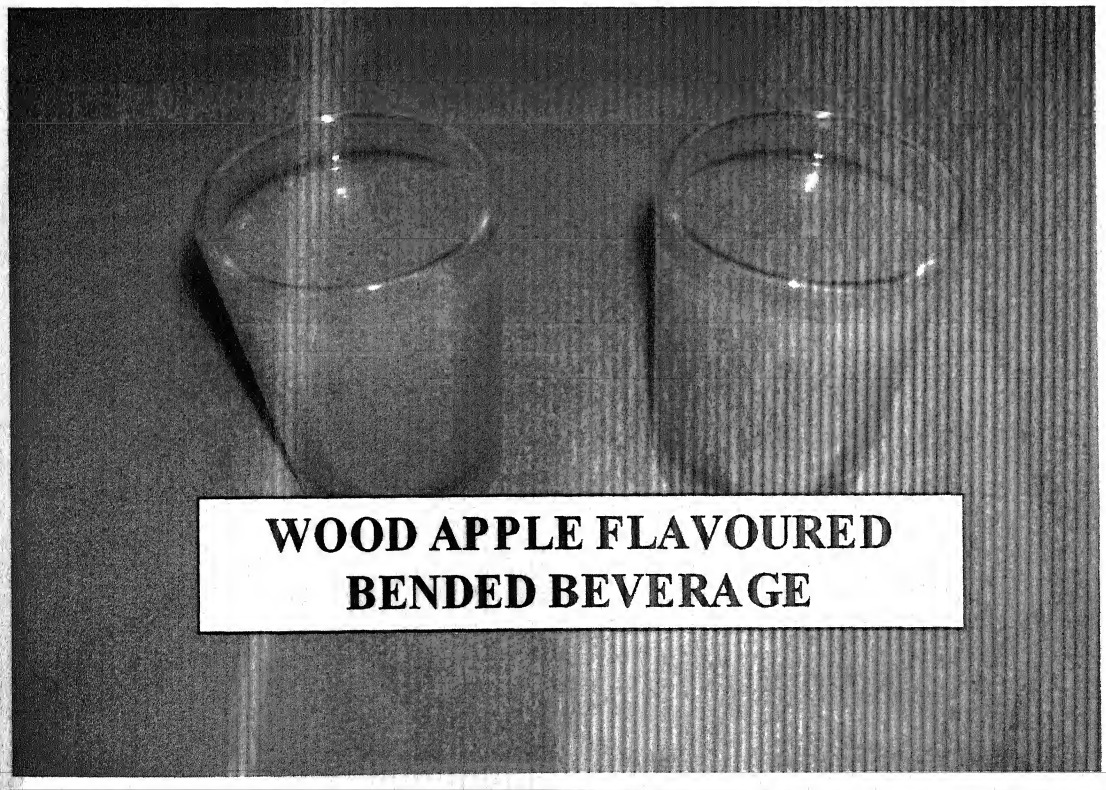


Fig. 3.4: Preparation of Wood Apple blended beverage



WOOD APPLE BLENDED BEVERAGE



WOOD APPLE FLAVOURED BENDED BEVERAGE

PLATE-3

3.3.10.3 ***Optimization of carbon-dioxide gas***

The carbon-dioxide gas depends on the producing time of gas. Three types of producing time (2, 3 and 4 minutes) were used.

3.3.11 Method of Preparation

Pre-standardized percentage of Wood Apple pulp (20 percent) was mixed with little amount of water, sieved with the help of muslin cloth. Standardized amount of sugar (15 per cent) was used in the preparation of sugar syrup. Standardized ratio of carbon-dioxide (3 minute) gas was dissolve in the water. Pulp extract and sugar syrup were blended with carbonated water filled in pre sterilized glass bottles and stored at refrigeration temperature (2-5°C). The flow diagram for the preparation of Wood Apple carbonated drink is presented in Fig. 3.5.

3.3.12 Development of Wood Apple Powder

3.3.12.1 ***Optimization of temperature***

Fruit pulp was dried at four different temperatures 50, 60, 70 and 80 °C for 24 hr. The pulp was turned in between of drying. The selection of drying temperature was done on the basis of colour of Wood Apple fruit.

3.3.13 Development of Chemically treated Wood Apple Powder

3.3.13.1 ***Optimization of KMS***

Potassium metabisulphite was mixed in Wood Apple pulp in three percentages 0.1, 0.3 and 0.5 percent. KMS was pulp before drying. The percentage of KMS was selected on the basis of acceptability and natural colour of the product.

3.3.14 Development of Wood Apple Aonla Powder

3.3.14.1 ***Optimization of Aonla powder***

In the development of Wood Apple Aonla powder, Aonla powder was mixed with chemically treated Wood Apple powder in three different ratios of 30:70, 20:80 and 10:90. The percentage of Aonla powder was accepted on the basis of sensory evaluation.

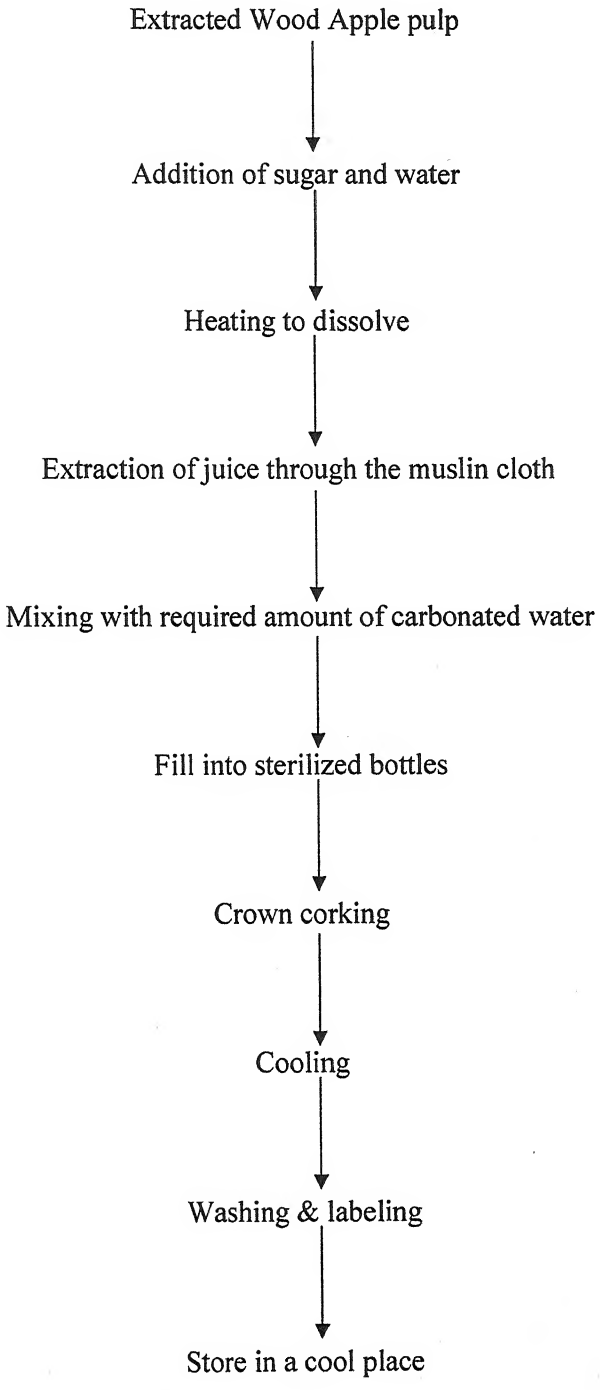


Fig. 3.5: Preparation of Wood Apple carbonated drink

3.3.15 Development of Wood Apple Ginger Powder

3.3.15.1 *Optimization of Ginger powder*

Ginger powder was mixed with chemically treated Wood Apple powder in the ratio of 15:85, 10:90 and 05:95.

3.3.16 Method of Preparation

Fruits were washed in running water to remove adhered dust, dirt particles etc. Fruit was broken and pulp along with seeds and fibers was scooped out manually. Pulp was dried at 60°C for 24 hr, in between pulp was turned and dried upto the moisture content of 4 per cent. Dried pulp was ground, sieved, packed and stored at room temperature (16-35 °C). The flow diagram for the preparation of Wood Apple powder is presented in Fig. 3.6.

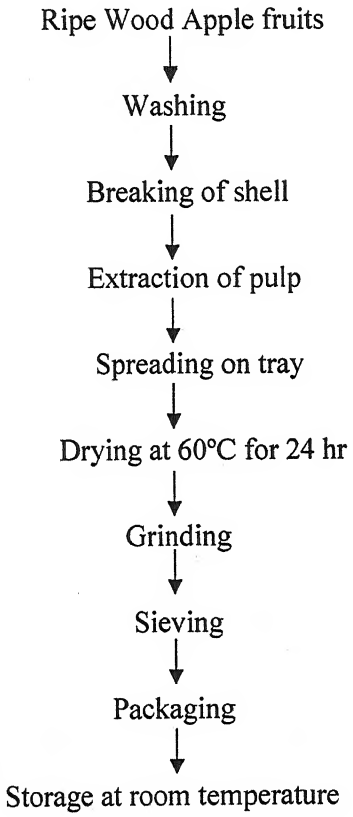
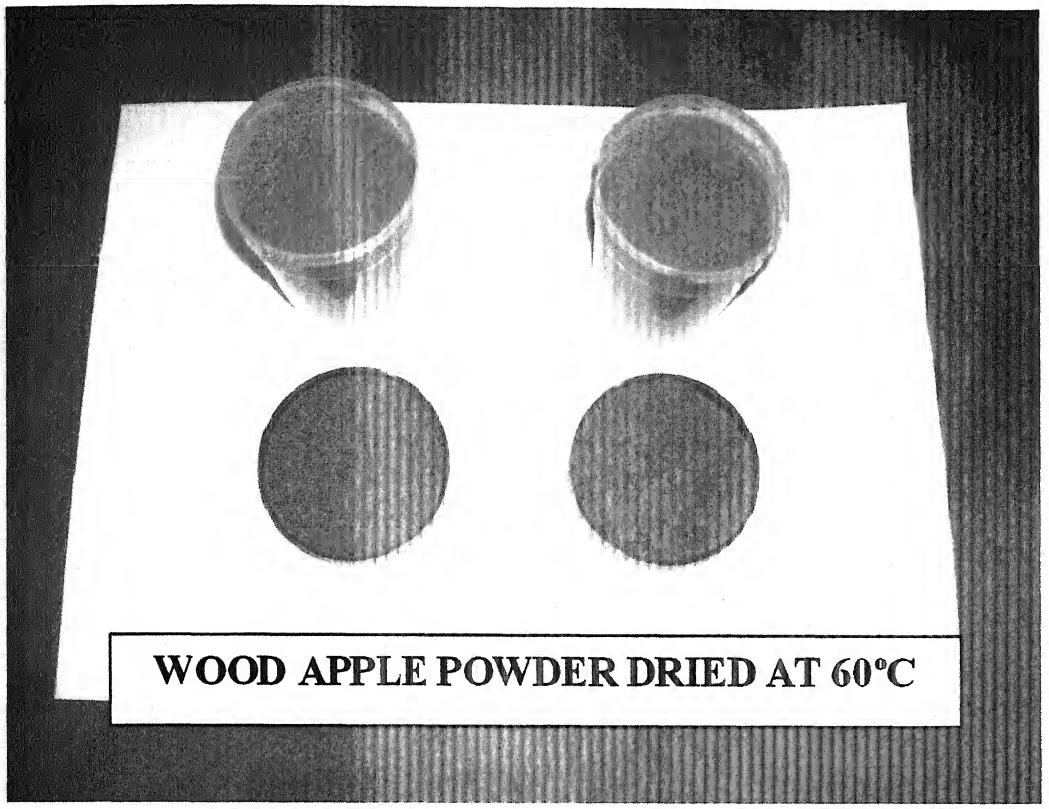
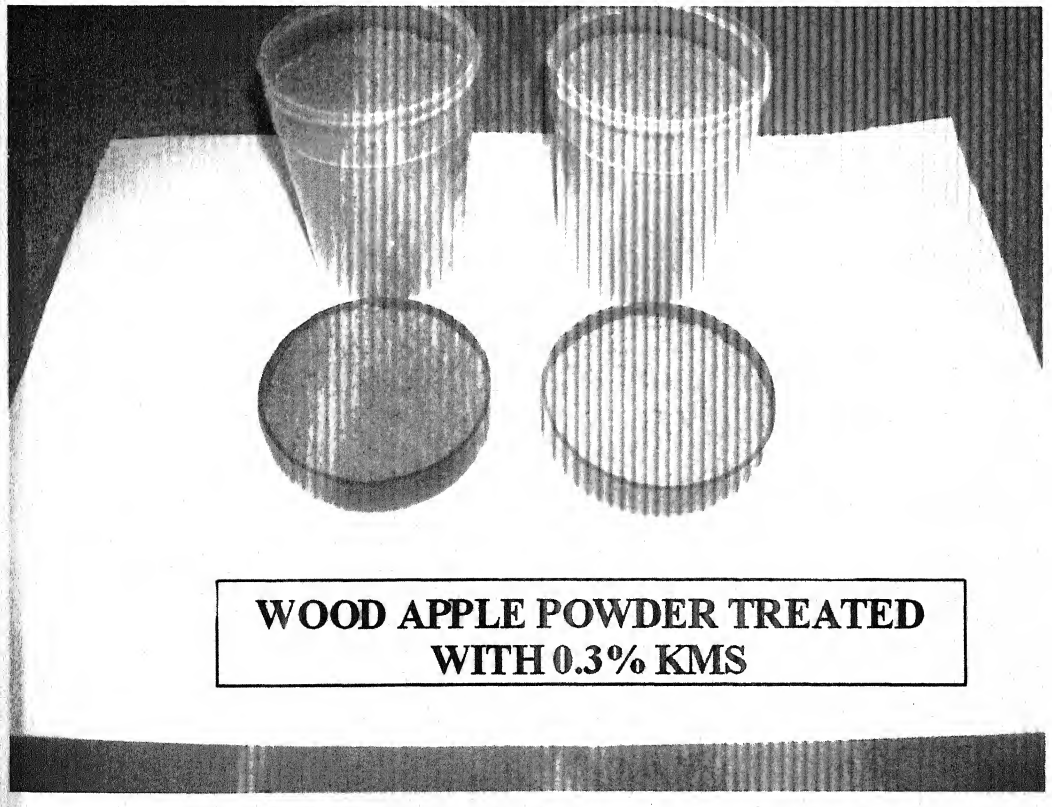


Fig. 3.6 Preparation of Wood Apple powder (control)

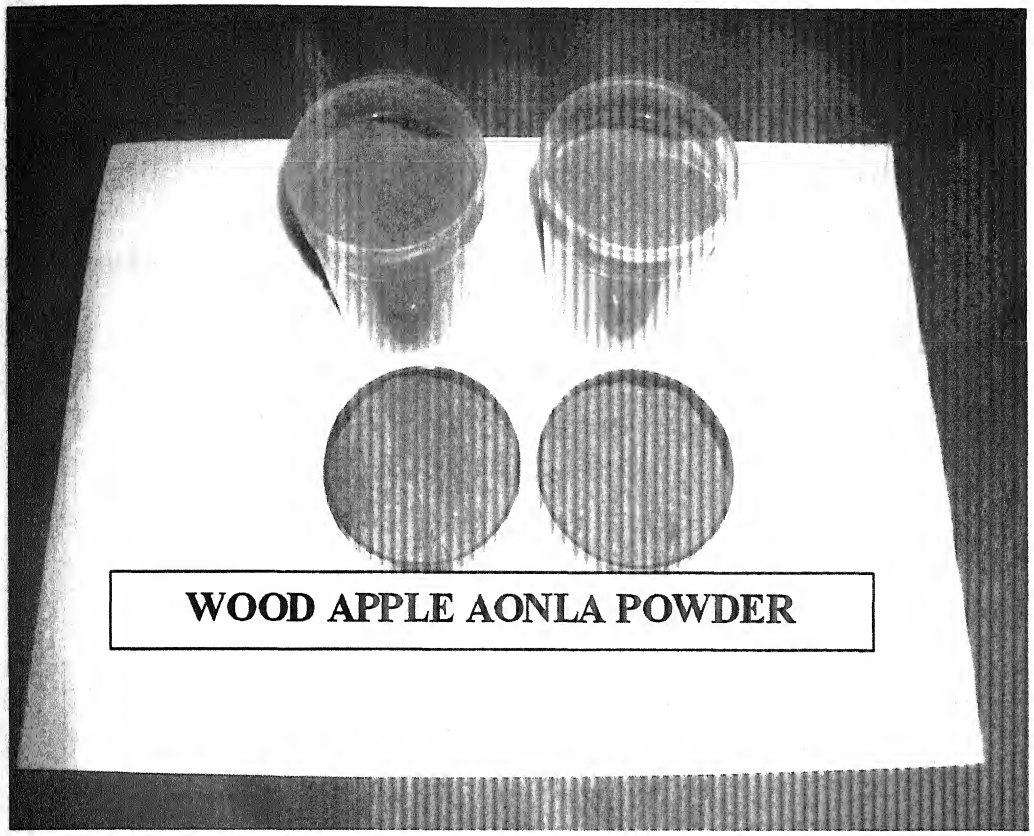


WOOD APPLE POWDER DRIED AT 60°C

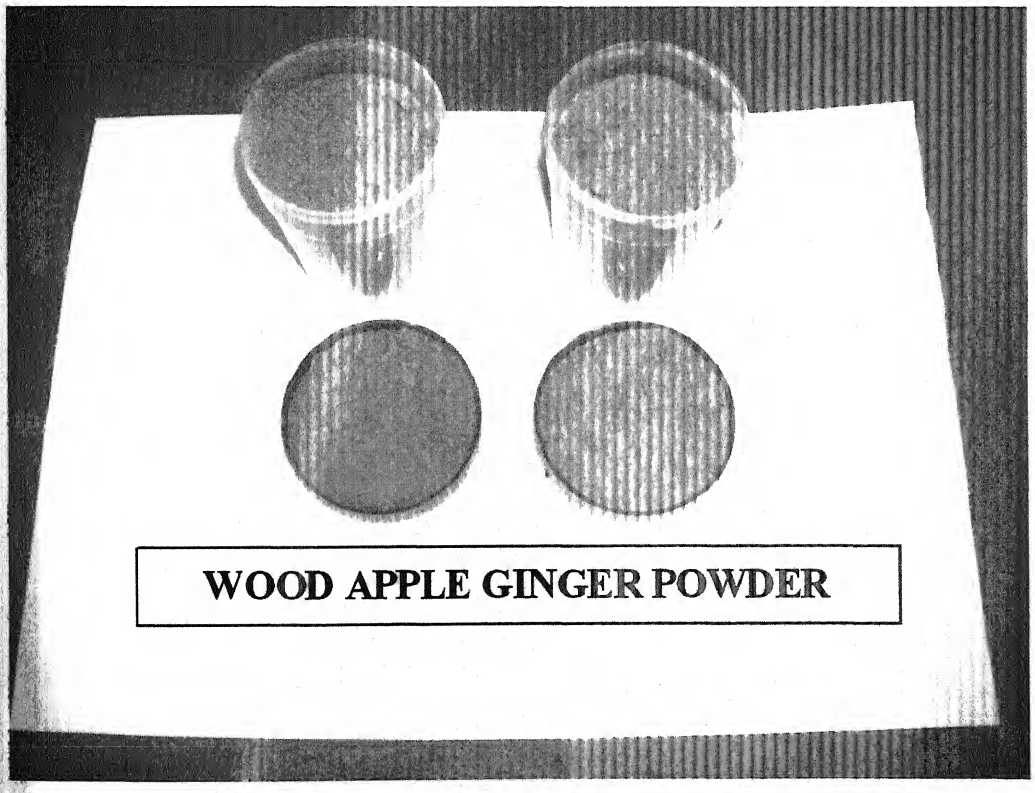


WOOD APPLE POWDER TREATED WITH 0.3% KMS

PLATE-4



WOOD APPLE AONLA POWDER



WOOD APPLE GINGER POWDER

PLATE-5

3.4 ANALYTICAL PROCEDURES

3.4.1 Chemical Analysis

Fresh Wood Apple fruits and Wood Apple products were analysed for moisture, protein, fat, carbohydrate, total ash, T.S.S., pH, acidity (as anhydrous citric acid), ascorbic acid, phosphorus, calcium, reducing sugar and total sugar.

3.4.1.1 *Moisture*

The moisture content of samples was determined by oven drying method (Ranganna, 1991). Aluminium disc was heated and weighed (W_1). 5 g sample was added in the disc and weighed (W_2). Disc was heated in hot air oven at 70±1°C until the constant weight was obtained; Disc was weighed (W_3). Moisture content was calculated by using the formula 3.1.

$$\text{Moisture (per cent)} = \frac{(W_2-W_3)}{(W_2-W_1)} \times 100 \qquad \ldots\ldots\ldots\ldots (3.1)$$

3.4.1.2 *Protein*

The protein content of sample was estimated by Kjeldahl method (using Pelican Equipment). Sample of 0.20 g was transferred into the protein digestion tube. Ten milliliters of concentrated sulphuric acid and 3 to 4 g of digestion mixture (Potassium sulphate and copper sulphate in the ratio of 5:1) was added to the tube. Digestion was carried out in the kjeldhal unit at 400°C till the contents become clear. The digested samples were cooled and diluted with some quantity of distilled water and tube was fitted into distillation unit. Digested sample was distilled for about 6 min with 40 per cent NaOH. Liberated ammonia was absorbed in 4 per cent boric acid solution containing a few drops of mixed indicator (one part of methyl red and one part of bromocresol green). The distillate was titrated against 0.1 N HCl until the brown blue colour changes to pink. A blank determination was carried out using all the reagents except sample. Nitrogen per cent was calculated by the following formula 3.2.

$$\text{Per cent Nitrogen} = \frac{(\text{Titre value} - \text{Blank}) \times 14 \times \text{Normality of acid} \times 100}{\text{Sample Weight} \times 1000}$$

$$\text{Per cent protein} = \%\,N \times 6.25 \qquad \ldots\ldots (3.2)$$

3.4.1.3 *Fat*

Fat content of the sample was estimated using soxtlet extraction method (Socsplus equipment of Pelican Equipment). 2g sample was weighed and transferred into the thimble that was inserted into the thimble holder. About 50 to 75 ml of petroleum ether (BP 60° to 80°C) was taken in beaker and the thimble is placed in the beaker. Beaker was placed in the system and the water tap was opened for condensation. The solvent was preheated at 100 to 120°C, solvent was boiled and allowed to stand for half an hour. When boiling was complete the temperature was increased by 20°C, depending upon the solvent temperature (80±20°C). Solvent was condensed in the beaker and allowed the condensed solvent to flow through the thimble to perform reclamation. When the reclamation process was complete, beakers were transferred to oven, maintained the temperature at 80°C to evaporate all the solvent from the beaker. The beakers were finally kept in desiccator, allowed to cool and weighed with fat. Fat percentage was calculated by using the formula 3.3.

$$\text{Fat (per cent)} = \frac{W_3 - W_2}{W_1} \times 100 \qquad \ldots\ldots\ldots (3.3)$$

Where,

W_1 = Weight of the sample

W_2 = Weight of the dried beaker, and

W_3 = Weight of beaker + fat

3.4.1.4 *Ash*

Ash content of the sample was estimated by incinerating the sample at 550°C in muffle furnace (Ranganna, 1991). Empty silica dish was weighed and approximately 2 g sample was taken in the same silica dish. Dish along with sample was placed over an electric heater and the product was allowed to charr and continued

till fumes came out of it. Cooled silica dish was placed in a muffle furnace, cooled in a desiccator and then weighed. Ash percentage was calculated by the following formula 3.4.

$$\text{Ash (per cent)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100 \quad \ldots\ldots\ldots (3.4)$$

Where,

W_1 = Weight of empty silica dish

W_2 = Weight of the sample + silica dish

W_3 = After ashing, weight of silica dish

3.4.1.5 *Carbohydrate*

Carbohydrate content of Wood Apple fruit or its product was obtained by difference method (Ranganna, 1991). The carbohydrate content was calculated by using Eq. 3.5.

Carbohydrates (per cent) = 100 - (moisture + ash + protein + fat) ..... (3.5)

3.4.1.6 *Total soluble solids*

Total soluble solids (T.S.S.) of the pulp and beverages were determined by using a hand refractometer (range 0-32°Brix, Erma). Average of three observation was taken as TSS of the sample. Refractometer reading was corrected to 20°C (Ranganna, 1986).

3.4.1.7 *pH and acidity*

The pH of pulp, fruit bar and beverages was determined using digital pH meter. Acidity of the pulp, bar and beverages were determined by titrating them with standard 0.1N NaOH. Phenolphthalein was used as indicator. Acidity of samples was expressed as per cent anhydrous citric acid.

3.4.1.8 *Sugars*

Total and reducing sugars were determined by Lane and Eynon (1923) method.

3.4.1.8.1 ***Preparation of samples***

Samples were prepared by blending fruit pulp, bar and beverages with water and neutralizing it with 1N NaOH, boiled with 400 ml of distilled water for 1hr. Extracted sample was transferred to a 500 ml. flask and volume was made upto 500ml. with distilled water. Sample was filtered through Whatman No. 4 filter paper and 100 ml. of 45 per cent neutral lead acetate solution. It was allowed to stand for 10 min., excess of lead acetate was precipitated using 22 per cent potassium oxalate solution, volume was made upto 250 ml. and filtered.

3.4.1.8.2 ***Reducing sugar***

The prepared sample (sugar solution) was taken in a burette and titrated against 10 ml of pre standardized mixed Fehling's solution, using methylene blue as indicator until brick red colour was observed. The procedure of titration was carried out over hot plate.

Percentages of reducing sugars were calculated using the Eq. 3.6.

$$\text{Reducing sugar or total sugar (\% invert sugar)} = \frac{\text{Fehling factor} \times \text{Dilution}}{\text{Titre} \times \text{Weight of Sample} \times 1000} \times 100 \quad \ldots\ldots\ldots (3.6)$$

3.4.1.8.3 ***Total sugars***

For estimation of total sugars, prepared sample (50 ml) was inverted by adding 5.0 g of citric acid and 50 ml distilled water were added and boiled over a hot plate for 10 min. to ensure inversion of sugars. The inverted sample was cooled to room temperature, neutralized with 1N NaOH, the volume was made upto 250 ml with distilled water and titrated as in the case of reducing sugars section (3.4.1.8.2). Percentage of reducing sugars was calculated using Eq. 3.6.

3.4.1.9 ***Ascorbic acid***

Ascorbic acid was determined by 2,6 dichlorophenol indophenol visual titration method (Ranganna, 1991). Sample was prepared by blending 5.0 g sample with 3 per cent HPO_3 and volume was made up to 100 ml using 3 per cent HPO_3.

Dye was standardized against standard ascorbic acid solution (0.1 mg ascorbic acid per ml solution). Sample (10 ml) was titrated with the dye to a pink end point which persisted for 15 sec. The ascorbic acid was expressed as mg ascorbic acid per 100 gm sample and calculated using Eq. 3.7.

$$\text{Ascorbic acid (mg per cent)} = \frac{\text{Titre x dye factor x volume made up x 100}}{\text{(Aliquot of extract taken x weight of sample taken for estimation}} \quad \ldots\ldots (3.7)$$

3.4.1.10 ***Minerals***

Ash obtained from 5 g of sample was boiled with 25 ml of 10 per cent hydrochloric acid for 30 min and filtered through an ash less filter paper (Whatman No. 42), washed with hot water until washings was acid free. The filtrate was made up to 100 ml and retained for the estimation of calcium, phosphorus.

3.4.1.10.1 ***Calcium***

Calcium content in sample was determined by procedure described by Ranganna (2003). Thirty ml of ash solution (obtained as per above), 25 ml of distilled water and 10 ml of saturated ammonium oxalate were taken in a beaker. To this, 2 drops of methyl red indicator were added and the pH of the contents was adjusted to 5.0 using dilute ammonia (1:1) and dilute acetic acid (1:4) solution. The contents were boiled and left at room temperature for overnight. Next day, the contents were filtered through Whatman No. 42 filter paper. The residue thus obtained was washed with hot distilled water until it became oxalate free. The filter paper was broken by a pointed glass rod and washed with 10 ml of hot dilute sulphuric acid (1:4) followed by distilled water. The contents were heated to 80°C and titrated against 0.01N potassium permanganate to a stable pink colour. Finally, the filter paper was also dropped in the solution and titration was completed. Calcium content was calculated by using Eq. 3.8.

$$\text{Calcium (mg/100g)} = \frac{\text{Titer value} \times \text{Normality of } KMnO_4 \times \text{Total volume of ash solution} \times 100}{\text{ml. of ash solution taken for estimation} \times \text{Weight of sample taken for ashing}} \quad \ldots\ldots (3.8)$$

3.4.1.10.2 ***Phosphorous***

Phosphorus content was estimated according to the procedure described by Ranganna (2003). Five ml of ash solution and 5 ml of molybdate reagent (25 g of ammonium molybdate dissolve in 400 ml of distilled water, added 500 ml of 10 N sulphuric acid and final volume made up to 1 litre with distilled water) were taken in a 50 ml volumetric flask. To this, 2 ml of aminonaphtholsulphonic acid solution (0.5 g 1-amino-2naphthol-4sulphonic acid, 30 g sodium bisulphite and 6 g sodium sulphite, dissolve in 250 ml of water, left for overnight and filtered) was added and made up the volume to 50 ml with using distilled water. For blank preparation, distilled water used in the place of sample. This was allowed to stand for 10 min and the colour was measured at 650 nm in a spectrophotometer. For standard, 0.4389 g potassium dihydrogen phosphate and 10 ml of 10 N sulphuric acids were dissolve in distilled water and the volume was made up to 1 litre. Five ml of this solution was used for analysis. The phosphorus content was calculated by using Eq. 3.9.

$$\text{Phosphorus (mg/100g)} = \frac{\text{Mg of phosphorus in aliquot of ash solution taken for estimation} \times \text{Total volume ash solution} \times 100}{\text{ml of ash solution taken for estimation} \times \text{Weight of sample taken for ashing}} \quad \ldots\ldots (3.9)$$

3.4.2 Rheological Analysis

3.4.2.1 *Texture profile analysis*

The texture analyzer (model TAXT2i) was calibrated at the beginning of each testing session using a 25 kg load cell. A compression plate (P 75, 75 mm diameter) and cutting probe (HDP/LKB light knife blade perspex) were used in conjunction with a texture analyzer (Boune 1982) for the determination of sticking characteristics and cutting strengh. A 25 kg maximum load cell was used and the pre test speed was set at 2.0 mm for a total travel of 10 mm. Data acquisition was initiated using a trigger force. Cutting strength was measured the pre test speed at 2.0 mm for a total travel of 3.0 mm for bar samples by keeping the bar horizontally and cutting with vertical blade. The force required was noted.

3.4.3 Microbiological Analysis

Total plate count, yeast and mould count and coliform count of fresh and stored beverage samples were determined as per the standard methods given in APHA (1992). Samples were inoculated in duplicate plates of suitable media and incubated at the recommended temperature (Table 3.1). At the end of incubation period, the plates were counted for number of colonies.

Table 3.1: Media and incubation condition for microbial examination

Determination	Medium		Incubation	
	Type	pH	Temperature (°C)	Period (hr)
Total plate count	Plate Count Agar	7	37	24-48
Yeast and mold count	Potato Dextrose Agar	3	22	72-110
Coliform count	Violet Red Bile Agar	7	37	24-48

3.4.4 Sensory Analysis

A panel consisting of 10 members was selected for sensory evaluation. Fruit bar samples and water were presented to panelists drawn from the faculty members and students of the department for evaluation. The panelists were asked to judge the samples for colour, flavour, body and texture, chewness and overall acceptability

using a 9-point hedonic scale rating (Amerine, *et al.,* 1965) as per the performa (Appendix I).

3.4.5 Statistical Analysis

Data was subjected to statistical analysis using ANOVA with statistical software (Systat 11 soft ware).

3.4.6 Storage Studies

Wood Apple fruit bar prepared by using optimized level of ingredients (Mango pulp and sugar) was packed in aluminium foil and stored in the room temperature for storage study. Wood Apple beverages (nectar, blended beverage and carbonated drink) were prepared by using optimized level of ingredients (Wood Apple pulp, Mango pulp, Ginger pulp, sugar, citric acid, potassium metabisulphite and carbon dioxide gas). Beverages were packed in 200 ml glass bottles and pasteurized in boiling water bath at 92.5°C for 10 min. Bottles were air cooled to room temperature and stored under refrigeration (2-5°C) for storage study.

Samples were analysed for changes in moisture, protein, ash, minerals (calcium and phosphorus), TSS, pH, acidity, sugars (reducing and total sugars), and ascorbic acid. Microbiological and sensory attributes of the beverages were also evaluated.

RESULT AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1 CHEMICAL COMPOSITION OF PULP

4.1.1 Wood Apple Pulp

Wood Apple is a hardy fruit. It is round in shape, grayish white in colour with sweet and sour pulp, contained numerous seeds, scattered into it. The Wood Apple fruit also known as Elephant Apple, Monkey fruit, Curd fruit and *Kath Bel.* The Wood Apple fruit belongs to the family *Rutaceae.*

Wood Apple pulp contains 72.4 per cent of moisture (Table 4.1). Gopalan *et al.* (1994) reported that the moisture content in Wood Apple fruit was 64.2 per cent and 70.6 per cent was observed by Joshi and Jain (2008) while 74.0 per cent moisture was noted by Morton (1987).

The protein content in Wood Apple pulp was 7.2 per cent. Joshi and Jain (2008) reported 7.5 per cent protein in Wood Apple while 7.1 and 8.0 per cent were reported by Gopalan *et al.* (1994) and Morton (1987), respectively.

The value of fat content in Wood Apple pulp was found 2.07 per cent. Morton (1987) reported 1.45 per cent fat content while 3.3 per cent was reported by Joshi and Jain *et al.* (2008). Gopalan *et al.* (1994) reported fat content of 0.3 per cent in Wood Apple.

The ash content in the Wood Apple pulp was 3.20 per cent. Ash content of 4.6 per cent was reported by Joshi and Jain (2008) while Morton (1987) observed the ash content of 5.0 per cent in Wood Apple pulp.

The carbohydrate content in Wood Apple pulp was 15.13 per cent as calculated by difference method. Morton (1987) had reported 7.45 per cent carbohydrate while 17.0 per cent was observed by Gopalan *et al.* (1994). The percentage of carbohydrate content in Wood Apple was 22.1 per cent (Joshi and Jain, 2008).

The ascorbic acid content in Wood Apple pulp was 66.4 mg/100g. Joshi and Jain (2008) reported that the ascorbic acid content in Wood Apple was 15.9 mg/100g on fresh weight basis while 3.0 mg/100g ascorbic acid content was observed by Gopalan *et al.* (1994).

The value for calcium content of Wood Apple pulp was 188.8 mg/100gm. Gopalan *et al.* (1994) reported the value of calcium 4.0 mg/100g while 12.0 mg/100gm calcium content was observed by Priyanka and Shashi (2008).

Wood Apple pulp contains 98.8 mg /100g phosphorus while 9.0 mg/100g was reported by Gopalan *et al.* (1994).

The TSS content in Wood Apple pulp was 13.2°Brix while 14.32°Brix was observed by Singh *et al.* (2000). The value of pH of Wood Apple pulp was 3.4.

The acidity of Wood Apple pulp was 3.18 per cent. Gopalan *et al.* (1994) reported the value of acidity was 2.3 per cent while 4.15 per cent was observed by Singh *et al.* (2000).

4.1.1.1 *Standardization of flesh water blend ratio*

Wood Apple fruit was used in the present study because of their higher content of edible portion (48.64%) and the lowest content of seed (2.84%) and fibre (2.90%). For the extraction of Wood Apple pulp, flesh and water blends were prepared separately by manual mixing of flesh and water in four different ratios of 1:05, 1:1, 1:2 and 1:3 at 100°C (Table 4.2). Flesh was added in water in 1:2 ratio and heated to 100°C was concluded to be the ideal blend (flesh to water ratio 1:2). The flesh and water ratio of 1:2 was found best in the investigation of Chopra and Singh (2001).

4.1.1.2 *Organoleptic evaluation of Wood Apple pulp*

The sensory evaluation of Wood Apple pulp was undertaken on a 9 point hedonic scale by 10 members, on the different quality parameters (colour, flavour, taste and overall acceptability). The data of the same was analysed to test the significance between the pulp samples (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

Table 4.1: Chemical constituents of Wood Apple pulp

Constituents	Percentage
Moisture (%)	72.4
Protein (N x 6.25)	7.2
Fat (%)	2.07
Ash (%)	3.20
Carbohydrate (% by difference)	15.13
Ascorbic acid (mg/100gm)	66.40
Calcium (mg/100gm)	188.8
Phosphorus (mg/100gm)	98.8
TSS (°Brix)	13.2
pH	3.4
Acidity (%)	3.18

Table 4.2: Effect of dilution and ease of filtration at 100°C temperature

S.N.	Flesh to water ratio	Ease of filtration
1	**1:0.5**	Too viscous to pass through sieve
2	**1:1**	Viscous but pass through sieve
3	**1:2**	Passed through sieve easily
4	**1:3**	Passed through sieve more

The sensory score for colour of pulp samples was in the range of 6.8 to 7.0 respectively (Table 4.3). There was no appreciable change in the colour of the flesh water blends and were non significantly different.

The flavour scores for flesh water blends were 6.1, 7.0 and 5.8 for 1:1, 1:2 and 1:3 (flesh: water) respectively (Table 4.3). The highest flavour score of 7.0 was found for 1:2 ratio of flesh and water. The flavour score for 1:2 ratio of flesh and water was significantly different ($P \leq 0.05$) in comparison to other blends (CD = 0.81). Chopra and Singh (2001) also found significant difference in flavour score (6.05) of 1:2 flesh water blend.

The taste scores for flesh water blends were 6.94, 7.5 and 5.5 for 1:1, 1:2 and 1:3 ratio (flesh: water) respectively. The highest taste score of 7.5 was found for 1:2 ratio of flesh and water (Table 4.3). The taste score for 1:2 ratio of flesh and water was significantly different ($P \leq 0.05$) in comparison to other blends (CD = 0.98). Chopra and Singh (2001) also found significant difference in taste score (6.83) of 1:2 flesh water blend.

The sensory scores of overall acceptability were 6.64, 7.16 and 6.03 for 1:1, 1:2 and 1:3 (flesh: water) respectively (Table 4.3). Overall acceptability score of pulp sample produced from 1:2 blend heated at 100°C was significantly higher (7.16) than other blends. The overall acceptability score for 1:2 ratio of flesh and water was significantly different ($P \leq 0.05$) in comparison to other blends (CD = 0.62). Chopra and Singh (2001) also found significant difference in overall acceptability score (6.39) of 1:2 flesh water blend.

4.1.1.3 *Pulp treated with Enzyme for juice preparation*

Wood Apple pulp was treated with Enzyme (Tryzyme) in three different percentages 0.5, 1.0 and 1.5. No appreciable change was observed in the juice.

4.1.1.4 *Extraction of oleoresin*

Oleoresin was extracted from Wood Apple seeds with the help of hexane. For the extraction of oleoresin from seeds solvent extraction method was used. The percentage of oleoresin in Wood Apple seeds was about 13.2 per cent.

4.1.2 Mango pulp

Mango pulp contains 82.2 per cent of moisture (Table 4.4). This value is quite similar to the value of 83.0 per cent reported by Chauhan *et al.* (1998) while 87.0 and 87.8 per cent reported by Chauhan *et al.* (1997) and Singh *et al.* (2003). Roy and Rao (1980) and Mir and Nath (2000) reported the moisture content in Mango pulp is 78.2 per cent and 78.4 percent, respectively.

The value of protein in Mango pulp was 0.64 per cent. This value is almost similar to 0.65 per cent reported by Chauhan *et al.* (1997) while the value 0.60 percent reported by Mir and Nath (2000).

The fat content of Mango pulp was 0.39 per cent is quite similar to the value of 0.41 percent reported by Chauhan *et al.* (1997) while 0.53±0.02 per cent reported by Chauhan *et al.* (1998).

Ash content of Mango pulp was 0.74 per cent. Ash content 0.72 per cent was reported by Chauhan *et al.* (1997) while Mir and Nath (2000) observed 0.70 per cent ash content in Mango pulp.

The carbohydrate content of Mango pulp was 16.03 per cent. This value of carbohydrate is lower than 20.2 per cent reported by Mir and Nath (2000).

The ascorbic acid of Mango pulp was 16.42 mg/100gm is almost similar to 16.40 mg/100g reported by Roy and Rao (1980) while a value of 16.50±0.3 mg/100g was reported by Chauhan *et al.* (1997).

The value of pH in Mango pulp was 4.55. This value is quite similar to 4.0 reported by Srivastava (1998). Chauhan *et al.* (1997) and Chauhan *et al.* (1998) reported the pH value of 3.85±0.1 and 4.75±0.15 in mango pulp, respectively.

The acidity content in the Mango pulp was 0.16 per cent, that value of acidity is quite lower than 0.18 per cent reported by Srivstava (1998) and Roy *et al.* (1972), respectively. Acidity of 0.26 per cent and 0.29 per cent was reported by Mir and Nath (2000) and Singh *et al.* (2003), respectively. Chauhan *et al.* (1997 and 1998) reported was 0.55 and 0.62±0.02 per cent acidity in Mango pulp.

Table 4.3: Organoleptic evaluation of Wood Apple pulp

S.N.	Flesh to water ratio	Colour	Flavour	Taste	Overall Acceptability
1	**1:1**	6.9	6.1	6.94	6.64
2	**1:2**	7	7	7.5	7.16
3	**1:3**	6.8	5.8	5.5	6.03
4	**CD (5%)**	NS	0.81	0.98	0.62
5	**P value**	0.08	0.04	0	0.02

Table 4.4: Chemical constituents of Mango pulp

Constituents	Percentage
Moisture (%)	82.2
Protein (N x 6.25)	0.64
Fat (%)	0.39
Ash (%)	0.74
Carbohydrate (% by difference)	16.03
Ascorbic acid (mg/100gm)	16.42
pH	4.55
Acidity (% as CA)	0.16
TSS	16.5
Total Sugars (%)	16.4
Reducing Sugar (%)	2.45
Non-Reducing Sugar (%)	13.95

The TSS content of Mango pulp was 16.50°Brix. It was similar to the value of 16.50±20° Brix reported by Chauhan *et al.* (1998). Singh *et al.* (2003), Chauhan *et al.* (1998), Rao and Roy (1980), Srivastava (1998) and Roy *et al.* (1972) reported the TSS value in the range of 17°Brix to 22.5°Brix.

The value of total sugar in Mango pulp was 16.40 per cent. The value of total sugar was 16.42 per cent reported by Rao and Roy (1980). Mir and Nath (2000), Srivastava (1998) and Roy *et al.* (1972) observed a higher value of total sugar in the range of 17.2 per cent to 19.2 per cent, respectively.

The reducing sugar of Mango pulp was 2.45 per cent. Rao and Roy (1998) and Singh *et al.* (2003) reported similar values of reducing sugar (2.47 per cent to 2.70 per cent), respectively. The values of reducing sugar in the range of 3.0 per cent to 7.5 per cent reported by Roy *et al.* (1972), Mir and Nath (2000), Chauhan *et al.* (1997) and Srivastava (1998).

Non reducing sugar of Mango pulp was 13.95 per cent. This was almost similar to the value of 13.95 per cent reported by Rao and Roy (1980). Roy *et al.* (1972) reported the value of non reducing sugar was 16.2 per cent and 9.9 per cent was observed by Srivastava (1998).

4.1.3 Papaya Pulp

The moisture per cent in Papaya pulp was 88.4 per cent (Table 4.5) while 87.90 per cent was reported by Balasubramanian (2007). The acidity content in Papaya pulp was 0.22 while 0.25 per cent was observed by Balasubramanian (2007). The pH value of Papaya pulp was 5.52 while Balasubramanian (2007) reported the pH value of 5.33. The TSS content in Papaya pulp was 12.8°Brix while 11.00°Brix was reported by Balasubramanian (2007). The ascorbic acid in Papaya pulp was 12.9 mg/100g while 13.8 mg/100g was reported by Balasubramanian (2007).

4.1.4 Ginger Pulp

Ginger contains 66.2 per cent of moisture (Table 4.6). Tripathi and Nath (2004) reported that the moisture content in Ginger was 68.6 per cent. The protein content in Ginger was 1.2 per cent while Tripathi and Nath (2004) reported 1.6 per cent protein in Ginger. The value of fat content in Ginger was 0.98 per cent while

Tripathi and Nath (2004) reported the fat content of 1.8 per cent in Ginger. The ash content in the Ginger was 0.4 per cent while 0.46 per cent was reported by Tripathi and Nath (2004). The carbohydrate content in Ginger was 31.22 per cent as calculated by difference method while 27.42 per cent was reported by Tripathi and Nath (2004). The ascorbic acid content in Ginger was 3.20 mg/100g while 3.1 mg/100g was observed by Tripathi and Nath (2004). The value of total sugar in Ginger was 3.12 per cent while 3.03 per cent was reported by Tripathi and Nath (2004). The value of reducing sugar in Ginger was 2.06 per cent while 2.17 per cent was reported by Tripathi and Nath (2004). The value of non reducing sugar in Ginger was 1.06 per cent while 2.17 per cent was reported by Tripathi and Nath (2004).

Table 4.5: Chemical constituents of Papaya pulp

Constituents	Quantity
Moisture (%)	88.8
pH	5.52
Acidity (%)	0.12
TSS°Brix	12.8
Ascorbic Acid (mg/100gm)	12.9

Table 4.6: Chemical constituents of Ginger

Constituents	Quantity
Moisture (%)	66.2
Protein %	1.2
Fat (%)	0.98
Ash (%)	0.4
Carbohydrate (%)	31.22
Ascorbic acid (mg/100gm)	3.20
Total Sugars (%)	3.12
Reducing Sugar (%)	2.06
Non-Reducing Sugar (%)	1.06

The study was conducted and the readings were observed at regular intervals. The following are the results obtained during the study.

4.2 PREPARATION OF THE BLENDED WOOD APPLE BAR

4.2.1 Standardization of the Parameters

Wood Apple pulp was blended with three different type of pulp i.e. Mango pulp, Ginger pulp and Papaya pulp in different ratios for the preparation of mixed fruit bar. Wood Apple and Mango pulp were mixed in 90:10, 70:30, 50:50 and 30:70 ratio, Wood Apple pulp and Ginger pulp were mixed in the ratio of 97:03, 95:05, 90:10 and 85:15 and Wood Apple and Papaya pulp were mixed in the ratio of 90:10, 70:30 and 50:50. The fruit bars were prepared and evaluated by a sensory panel of 10 members by using 9 point hedonic scale. The sensory scores were 6.25, 6.30, 7.85 and 6.08 for 90:10, 70:30, 50:50 and 30:70 ratio (Wood Apple pulp: Mango pulp) respectively. The highest sensory score of 7.85 was found for 50:50 ratio of Wood Apple pulp and Mango pulp (Table 4.7). The sensory score of 50:50 ratio was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.508).

The sensory scores for Wood Apple Papaya bar were 5.88, 7.35 and 5.62 for 90:10, 70:30, and 50:50 ratio (Wood Apple pulp: Papaya pulp) respectively. The highest sensory score of 7.35 was found for 70:30 ratio of Wood Apple pulp and Papaya pulp (Table 4.9). The sensory score of 70:30 ratio was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.608).

In case of Wood Apple Ginger bar the sensory scores were 6.77, 6.70, 7.79 and 6.75 for 97:03, 95:05, 90:10 and 85:15 ratio (Wood Apple pulp : Ginger pulp) respectively. The highest sensory score of 7.79 was found for 90:10 ratio of Wood Apple pulp and Ginger pulp (Table 4.8). The sensory score of 90:10 ratio was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.285).

4.2.1.1 *Standardization of sugar percentage*

Sugar content was standardized by incorporation of 20, 30 and 40 per cent sugar (Table 4.10). The sensory score for 30 per cent sugar was found highest (7.75) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.365).

Table 4.7: Standardization of the ratio of Wood Apple pulp with Mango pulp

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
WAP:MP(90:10)	6.30	6.05	6.55	6.40	5.95	6.25
WAP:MP(70:30)	6.55	6.00	6.25	6.55	6.15	6.30
WAP:MP(50:50)	8.05	7.65	7.95	7.85	7.75	7.85
WAP:MP(30:70)	6.15	6.00	6.05	5.90	6.30	6.08
CD (5%)	0.558	0.511	0.592	0.575	0.606	0.508
P value	0.01	0.01	0.02	0.02	0.04	0.01

Table 4.8: Standardization of the ratio of Wood Apple pulp with Papaya pulp

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
WAP:PP(90:10)	6.35	5.90	5.75	5.40	6.00	5.88
WAP:PP(70:30)	7.60	7.20	7.35	7.35	7.25	7.35
WAP:PP(50:50)	6.10	5.50	5.50	5.50	5.50	5.62
CD (5%)	0.544	0.700	0.737	0.823	0.704	0.608
P value	0.01	0.04	0.02	0.03	0.03	0.01

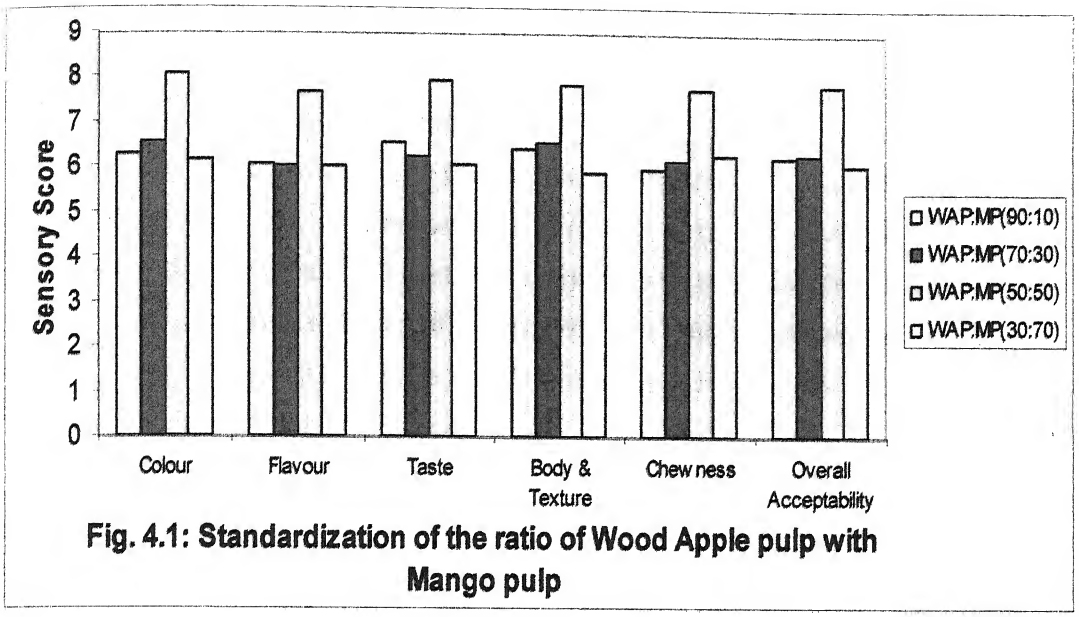


Fig. 4.1: Standardization of the ratio of Wood Apple pulp with Mango pulp

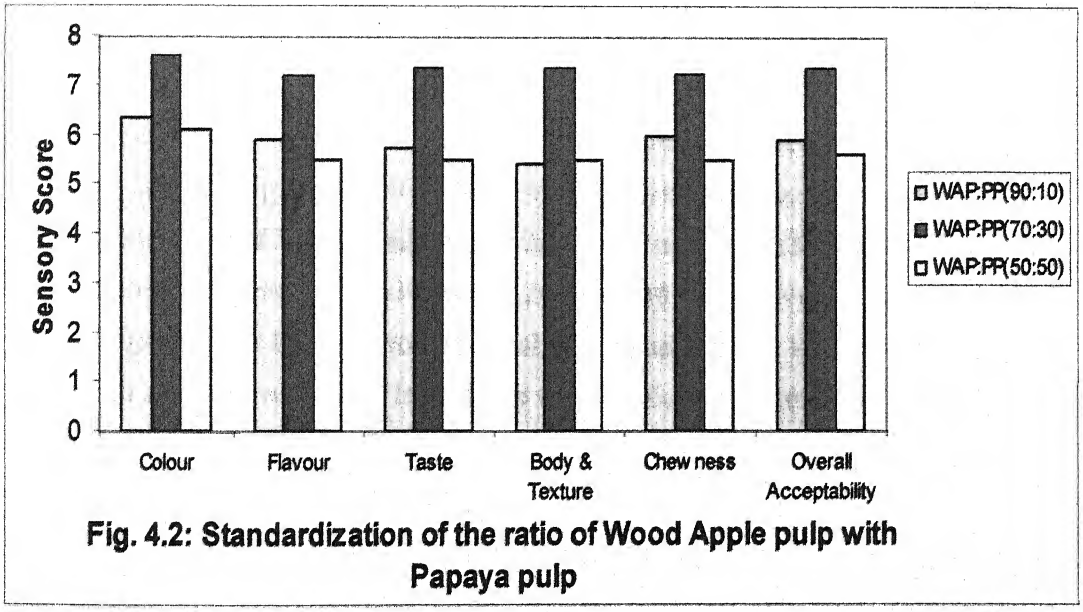


Fig. 4.2: Standardization of the ratio of Wood Apple pulp with Papaya pulp

The best score for 30 per cent sugar was due to low sweetness of 20 per cent sugar and very high sweetness for 40 per cent sugar content. The sugar content of 30 per cent was selected for further study.

4.2.1.1 *Standardization of sugar percentage*

Sugar content was standardized by incorporation of 20, 30 and 40 per cent sugar (Table 4.10). The sensory score for 30 per cent sugar was found highest (7.75) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.365). The best score for 30 per cent sugar was due to low sweetness of 20 per cent sugar and very high sweetness for 40 per cent sugar content. The sugar content of 30 per cent was selected for further study.

4.2.1.2 *Comparative acceptability of mixed fruit bar*

The sensory score for colour of the mix fruit bar made from Wood Apple pulp and Mango pulp in the ratio of 50:50 was best with the maximum score (7.90) followed by Wood Apple Papaya bar (7.30) in 70:30 ratio. The colour score of Wood Apple Ginger bar was 7.10 and it was not attractive and this might be due to the dark brown colour of the bar (Table 4.11). The colour of Wood Apple Papaya bar was less acceptable in comparison to Wood Apple Mango bar due to more pleasant colour of the later. There was significant change ($P \leq 0.05$) in the sensory score for colour of different combinations (CD = 0.283).

The sensory score for flavour of the mix fruit bar made from Wood Apple pulp and Ginger pulp in the ratio of 90:10 was best with the maximum score of 8.00. The flavour score of Wood Apple Mango bar in the ratio of 50:50 and Wood Apple Papaya bar in the ratio of 70:30 were 7.20 and 7.10, respectively. The flavour of Wood Apple Ginger bar was more acceptable in comparison to Wood Apple Mango bar due to strong flavour of the later. There was significant difference ($P \leq 0.05$) in the sensory score for flavour of different combinations (CD = 0.378).

The sensory score for taste of the mix fruit bar made from Wood Apple pulp and Mango pulp in the ratio of 50:50 was best with the maximum score (8.30) followed by Wood Apple Ginger bar (7.3) in 90:10 ratio. The taste score of Wood Apple Papaya bar was 7.20 and it was not much acceptable and this might be due to the unpleasant taste of Papaya pulp.

Table 4.9: Standardization of the ratio of Wood Apple pulp with Ginger pulp

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
WAP:GP(97:03)	6.75	6.85	7.00	6.08	6.45	6.77
WAP:GP(95:05)	6.90	6.70	6.70	6.75	6.45	6.70
WAP:GP(90:10)	7.60	7.85	8.10	7.60	7.80	7.79
WAP:GP(85:15)	6.75	6.60	6.75	6.75	6.90	6.75
CD (5%)	0.268	0.374	0.344	0.318	0.414	0.285
P value	0.02	0.01	0.00	0.04	0.01	0.00

Table 4.10: Standardization of the percentage of sugar in Wood Apple bar

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
Sugar (20%)	6.80	6.65	5.80	6.60	6.85	6.54
Sugar (30%)	7.80	7.70	7.80	8.00	7.45	7.75
Sugar (40%)	6.65	6.85	6.10	6.10	5.95	6.33
CD (5%)	0.488	0.241	0.857	0.660	0.576	0.365
P value	0.03	0.00	0.04	0.01	0.03	0.00

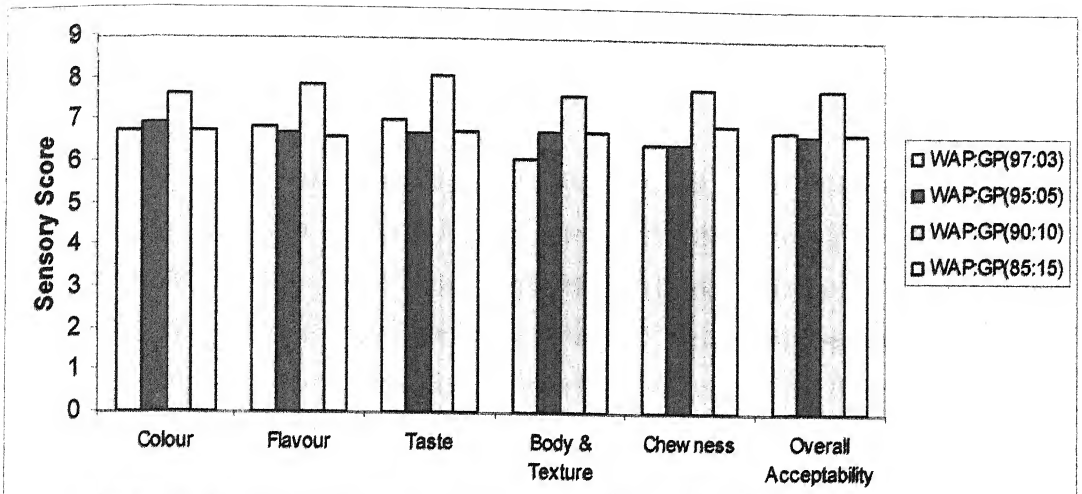


Fig.4.3: Standardization of the ratio of Wood Apple pulp with Ginger pulp

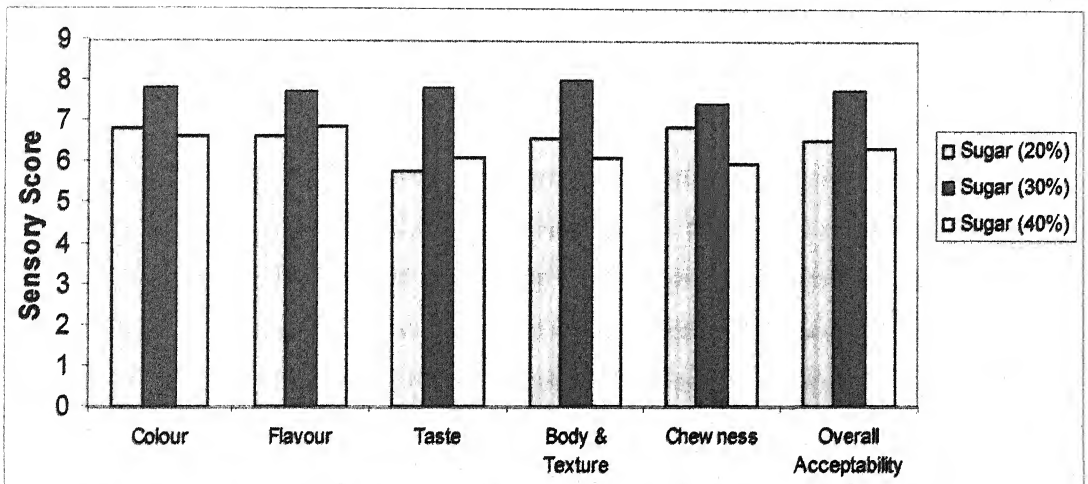


Fig. 4.4:Standardization of the percentage of sugar in Wood Apple bar

The taste of Wood Apple Ginger bar was less acceptable in comparison to Wood Apple Mango bar due to more pleasant taste of the later. There was significant difference ($P \leq 0.05$) in the sensory score for taste of different combinations (CD = 0.317).

Data sowed that the sensory scores for body and texture of bar samples were in the range of 6.30 to 7.40. The highest score (7.40) was recorded for Wood Apple Mango bar in the ratio of 50:50 and lowest for Wood Apple Ginger bar in the ratio of 90:10 and Wood Apple Papaya bar in the ratio of 70:30. Results show that the texture of bar samples could be improved considerably, when the product was prepared with the blending of Wood Apple pulp and Mango pulp. The Wood Apple Mango bar had good texture property and was significantly liked (7.40) more then any other bars. There was significant difference ($P \leq 0.05$) in the sensory score for body and texture of different combinations (CD = 0.359).

The sensory score for chewness of the mix fruit bar made from Wood Apple pulp and Mango pulp in the ratio of 50:50 was best with the maximum score of 7.30. The chewness score of Wood Apple Ginger bar in the ratio of 90:10 and Wood Apple Papaya bar in the ratio of 70:30 were almost similar (7.80 and 7.40, respectively). There was non significant difference in the sensory score for chewness of different combinations (CD = 0.416).

Data sowed that the sensory scores for overall acceptability of bar samples were in the range of 6.94 to 7.62. The sensory score for overall acceptability of the mix fruit bar made from Wood Apple pulp and Mango pulp in the ratio of 50:50 was best with the maximum score of 7.62. The overall acceptability score of Wood Apple Ginger bar in the ratio of 90:10 and Wood Apple Papaya bar in the ratio of 70:30 were almost similar (7.10 and 6.94, respectively). There was significant difference ($P \leq 0.05$) in the sensory score for overall acceptability of different combinations (CD = 0.157).

The mix fruit bar made from 50 per cent Wood Apple pulp and 50 per cent Mango pulp secured highest score of 7.62 among all combinations (Table 4.9) and was used for further study.

Table 4.11: Sensory evaluation of three types of Wood Apple bar

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
WAGB	7.10	8.00	7.30	6.30	6.80	7.10
WAMB	7.90	7.20	8.30	7.40	7.30	7.62
WAPB	7.30	7.10	7.20	6.70	6.40	6.94
CD (5%)	0.283	0.378	0.317	0.359	0.416	0.157
P value	0.18	0.03	0.00	0.01	0.08	0.00

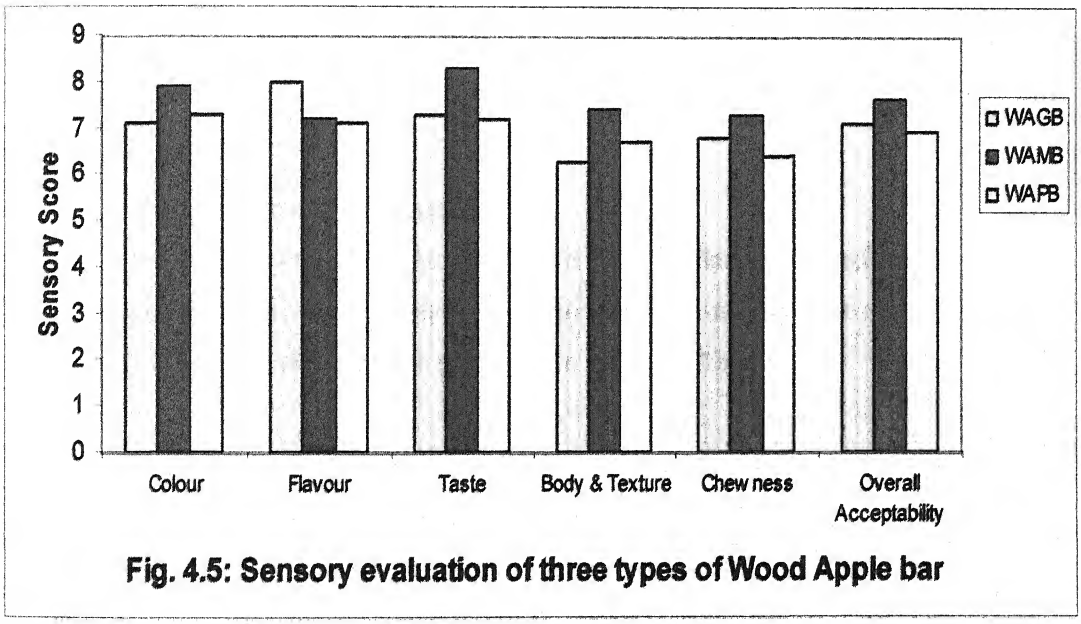


Fig. 4.5: Sensory evaluation of three types of Wood Apple bar

4.2.2 Storage Study

The selected Wood Apple Mango bar was stored for the storage study. The Wood Apple Mango bar was wrapped in aluminium foil and packed in air tight polythene and stored at room temperature for six months. Physico-chemical characteristics were evaluated at the interval of 0, 1, 2, 3, 4, 5 and 6 months during storage at room temperature (16-35°C) and physico-chemical, organoleptic, textural and microbiological changes were observed.

4.2.2.1 *Physico-chemical characteristics*

The chemical constituents present in Wood Apple fruit influence the nutritional and storage qualities of the product. The Wood Apple bar (control) and Wood Apple Mango bar were analysed for proximate composition as per the approved methods. Moisture content was analysed by oven drying method, ascorbic acid content by titration method using 2, 6, dichlorophenol indophenol dye, total ash, total acidity (as anhydrous citric acid), carbohydrate, sugars (Lane and Eynon, 1923), TSS (Ranganna, 1986), protein by micro-kjeldahl method, fat by soxhlet extraction method, calcium and phosphorus were determined by the procedures described by Ranganna (2003). The pH of the bar was determined after blending it with 15 volumes of boiled distilled water. All constituents were analysed at the end of 0, 1, 2, 3, 4, 5 and 6 months of storage at room temperature (16-35°C).

4.2.2.1.1 *Physico-chemical changes*

The product was stored for six months and the changes in moisture, protein, fat, ash, carbohydrate, acidity, pH, TSS, sugars, minerals and vitamin were observed. The results of the observations are presented in Table 4.12 and 4.13.

The moisture content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 17.40 and 14.80 per cent, respectively. During the storage period the moisture content showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the moisture content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 17.40 and 14.80 per cent, respectively, which had decreased to 17.20 and 14.02 per cent after 1 month of storage. The change

in the moisture content of bar sample was significantly different (P≤ 0.05). The percentage of moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was 16.80 and 13.78, respectively. There was significant difference (P≤ 0.05) in the moisture content of the product during the storage period. The percentage of moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was 16.35 and 12.88, respectively and showed a significant difference (P≤ 0.05). The percentage of moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 15.76 and 11.60, respectively. The results showed regular decline in moisture content. The decline in the moisture content may be due to the evaporation of moisture from the bar during storage. The difference in the moisture content was significantly different (P≤ 0.05). The percentage of moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 14.64 and 11.15, respectively and showed a significant difference (P≤ 0.05). The moisture content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 13.52 and 10.95 per cent from initial moisture content of 17.40 and 14.80 per cent, respectively. The change in the moisture content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.043 and 0.035). Aruna *et al.* (1999) observed that the moisture content of Papaya bar decreased significantly from 19.62 to 17.40 per cent during 9 month storage. The results were found in conformity with the results observed in the present study.

The fat content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 0.48 and 0.46 per cent, respectively. During the storage period the fat content showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the fat content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial fat content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 0.48 and 0.46 per cent, respectively. The fat content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 1 month of storage was 0.48 and 0.46, respectively and that was similar to the initial fat content (0.48 and 0.46) and showed a non significant difference. The fat content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 0.47 and 0.45 per cent respectively. The fat content of Wood Apple fruit bar (control) after 3 month of storage was 0.46 per cent while in Wood Apple Mango bar the fat percentage after 3

month storage was 0.45 per cent that was similar to 2 month storage (0.45 per cent). There was no significant difference in the fat content. The fat content of Wood Apple fruit bar (control) after 4 month storage was 0.46 per cent and that was similar to the fat content after 3 month storage (0.46) while the percentage of fat content of Wood Apple Mango bar after 4 month storage was decreased to 0.44 and showed a non significant difference. The results showed slight changes in fat content but no appreciable change was observed. The percentage of fat content of Wood Apple fruit bar (control) after 5 month of storage was decreased to 0.45 while the fat content of Wood Apple Mango bar was 0.44 and that was similar to the fat content after 4 month storage (0.44). The fat content of Wood Apple fruit bar (control) after 6 month storage was 0.45 per cent and that was similar to the fat content after 5 month storage (0.45) while the percentage of fat content of Wood Apple Mango bar after 6 month storage was decreased to 0.43. The change in the fat content was non significant.

The protein content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 2.20 and 1.98 per cent, respectively. During the storage period the protein content showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the protein content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial protein content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 2.20 and 1.98 per cent, respectively, which had decreased to 2.18 and 1.96 per cent after 1 month of storage. The change in the protein content of bar sample was significantly different ($P \leq 0.05$). The percentage of protein content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 2.16 and 1.95, respectively. There was significant difference ($P \leq 0.05$) in the protein content of the product during the storage period. The percentage of protein content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 2.12 and 1.92, respectively and showed a significant difference ($P \leq 0.05$). The percentage of protein content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 2.10 and 1.90, respectively. The protein content showed regular decline in protein content. The difference in the protein content was significantly different ($P \leq 0.05$). The percentage of protein content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 1.98 and 1.88, respectively and showed a significant difference ($P \leq 0.05$). The protein content of Wood Apple fruit bar (control)

and Wood Apple Mango bar after 6 months of storage was decreased to 1.92 and 1.84 per cent from initial protein content 2.20 and 1.98 per cent. The change in the protein content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.006). The initial protein content of protein enriched Sapota bar was 9.60 g percent which had decreased to 9.31 g percent after six months storage was reported by Saravana and Manimegalai (2002). The results were found in conformity with the results observed in the present study, while Aruna *et al.* (1999) observed no significant changes on protein content (from 7.39 to 7.33 g percent) in cereal based Papaya powder during storage for 9 months.

The carbohydrate content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 78.70 and 81.64 per cent, respectively. A remarkable increase in the carbohydrate content of the Wood Apple fruit bar (control) and Wood Apple Mango bar was noted throughout the storage period. The changes in the carbohydrate content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 78.70 and 81.64 per cent, respectively, which had increased to 78.92 and 82.44 per cent after 1 month of storage. The change in the carbohydrate content of bar sample was significantly different (P≤ 0.05). The percentage of carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was increased to 79.34 and 82.68, respectively. There was significant difference (P≤ 0.05) in the carbohydrate content of the product during the storage period. The percentage of carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was increased to 79.83 and 83.61, respectively and showed a significant difference (P≤ 0.05). The percentage of carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 80.44 and 85.25, respectively. The results showed regular increase in carbohydrate content. The difference in the carbohydrate content was significantly different (P≤ 0.05). The percentage of carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 81.68 and 85.37, respectively and showed a significant difference (P≤ 0.05). The carbohydrate content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was increased to 82.86 and 85.62 per cent from initial carbohydrate content 78.7 and 81.64

per cent. The change in the carbohydrate content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.045 and 0.123).

The ascorbic acid content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 64.34 and 62.20 mg/100g, respectively. During the storage period the ascorbic acid content showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the ascorbic acid content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 64.34 and 62.20 mg/100g, respectively, which had decreased to 62.98 and 60.00 mg/100g after 1 month of storage. The change in the ascorbic acid content of bar sample was significantly different ($P \leq 0.05$). The value of ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 60.12 and 58.72 mg/100g, respectively. There was significant difference ($P \leq 0.05$) in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 58.86 and 56.14 mg/100g, respectively and showed a significant difference ($P \leq 0.05$). The value of ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 54.44 and 52.62 mg/100g, respectively. The results showed regular decline in ascorbic acid content. The decline in the ascorbic acid content may be due to the degradation of ascorbic acid during storage. The difference in the ascorbic acid content was significantly different ($P \leq 0.05$). The value of ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 52.62 and 48.06 mg/100g, respectively and showed a significant difference ($P \leq 0.05$). The ascorbic acid content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 50.18 and 46.78 mg/100g from initial ascorbic acid content of 90.86 and 85.76 mg/100g. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.025). The ascorbic acid content decreased in control and Mango bar during storage at room temperature (Chauhan *et al.*, 1997). Similar pattern of decreasing trend of ascorbic acid in Papaya bar during 9 month storage was reported by Aruna *et al.* (1999). The jack fruit bar samples showed reduction in ascorbic acid content from 7.30 to 4.75 mg mg/100g after 180 days of storage (Krishnaveni *et al.*, 1998).

Veeranan *et al.* (2005) observed that the initial ascorbic acid content in mixed fruit bar (50:50 ratio of Mango pulp: Banana pulp) was 6.6 mg/100g, which had reduced to 5.0 mg/100g after 5 months of storage. The results were found in conformity with the results observed in the present study.

The acidity of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 2.35 and 2.44 per cent. A gradual increase in the acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar was observed during the storage. The changes in the acidity content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial acidity of Wood Apple fruit bar (control) was 2.35 which had increased to 2.36 per cent after 1 month of storage and showed significant difference ($P \leq 0.05$) while the change in the acidity of Wood Apple Mango bar from zero day to 1 month was non significant (2.44 to 2.45). The percentage of acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was increased to 2.38 and 2.48, respectively. There was significant difference ($P \leq 0.05$) in the acidity of the product during the storage period. The percentage of acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was 2.42 and 2.50, respectively and showed a significant difference ($P \leq 0.05$). The percentage of acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 2.43 and 2.51, respectively. The results showed regular increment in acidity. The percentage of acidity was increased due to the conversion of sugars to acids during storage. The difference in the acidity was significantly different ($P \leq 0.05$). The percentage of acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 2.45 and 2.53, respectively and showed a significant difference ($P \leq 0.05$). The acidity of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was increased to 2.48 and 2.55 per cent from initial acidity of 2.35 and 2.44 per cent. The change in the acidity was significant at 5 per cent level of significance (CD = 0.006 and 0.025). Saravana and Manimegalai (2002) reported that protein enriched Sapota bar had acidity of 0.306 percent initially, which increased to 0.398 percent on 6 months of storage. Aruna *et al.* 1999 in their experiments on Papaya fruit bar had reported initial acidity of 1.20 percent (as citric acid), which increased to 1.39 percent on 9 month of storage. Doreyappa Gowda *et al.* (1995) noted an increase in acidity of Mango bar from 1.4 to 1.5 g percent after 6 months of storage. Similarly, Gayathri and Uthira (2008) prepared blended bars

(Mango pulp: Papaya pulp), standard-I (75:25) and standard-II (50:50). The acidity content of the standard fruit bars (standard-I and standard-II) increased from 0.5 and 0.55 per cent to 0.80 to 0.76 percent, respectively during 90 days of storage. The results were found in conformity with the results observed in the present study.

The pH of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 3.90 and 4.32, respectively. During the storage period the pH value showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the pH of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial pH of Wood Apple fruit bar (control) was 3.90 which had decreased to 3.86 per cent after 1 month of storage and showed significant difference ($P \leq 0.05$) while the change in the pH of Wood Apple Mango bar from zero day to 1 month was non significant (4.32 to 4.30). The value of pH of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 3.85 and 4.27, respectively. There was significant difference ($P \leq 0.05$) in the pH of the product during the storage period. The value of pH of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was 3.76 and 4.23, respectively and showed a significant difference ($P \leq 0.05$). The value of pH of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 3.70 and 4.19, respectively. The results showed regular decline in pH. Increase in acidity could be the reason for decrease in the pH of the fruit bars during storage. The difference in the pH was significantly different ($P \leq 0.05$). The value of pH of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 3.67 and 4.13, respectively and showed a significant difference ($P \leq 0.05$). The pH of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 3.63 and 4.07 per cent from initial pH of 3.9 and 4.32 per cent. The change in the pH was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.006 and 0.025). The protein enriched Sapota bar prepared by Saravana and Manimegalai (2002) had initial pH of 3.92, which decreased to 3.64 during storage period. Gayathri and Uthira (2008) also showed the declining trend of pH in blended fruit bars (Mango pulp: Papaya pulp) from 4.5 to 4.0. The results were found in conformity with the results observed in the present study.

The TSS of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 78.90 and 78.10°Brix, respectively. A remarkable increase in the TSS

of Wood Apple fruit bar (control) and Wood Apple Mango bar was observed during the storage. The changes in the acidity content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12a and 4.13a). The initial TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar was 78.90 and 78.10°Brix, respectively, which had increased to 78.92 and 78.20°Brix after 1 month of storage. The change in the TSS of bar sample was significantly different ($P \leq 0.05$). The value of TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was increased to 78.98 and 78.40°Brix, respectively. There was significant difference ($P \leq 0.05$) in the TSS of the product during the storage period. The value of TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was 79.02 and 78.60°Brix, respectively and showed a significant difference ($P \leq 0.05$). The value of TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 79.08 and 78.8°Brix, respectively. The results showed regular increment in TSS. The increase may be due to the conversion of insoluble carbohydrates to soluble one. The difference in the TSS was significantly different ($P \leq 0.05$). The value of TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 79.12 and 78.80°Brix, respectively and showed a significant difference ($P \leq 0.05$). The TSS of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was increased to 79.16 and 78.9 °Brix from initial TSS of 78.90 and 78.10°Brix. The change in the TSS was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.006 and 0.061). A gradual increase in the TSS of the protein enriched Sapota bar from 68.0 to 68.9°Brix during the storage period of 180 days reported by Saravana and Manimegalai (2002). The TSS content in standard bars (I and II) increase from 57.8 and 57.3°Brix to 61.4 and 62.9°Brix (Gayathri and Uthira, 2008). The results of the present investigation were in conformity with the results observed by other investigators.

The total ash content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 1.22 and 1.12 per cent, respectively. An insignificant change in the total ash content of the Wood Apple fruit bar (control) and Wood Apple Mango bar was noted throughout the storage period. The changes in the total ash content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The initial total ash content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 1.22 and 1.12 per cent,

respectively. There was no appreciable change in the total ash content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 1 month of storage and that was 1.22 and 1.12 per cent, respectively. The total ash content of Wood Apple fruit bar (control) upto 3 months of storage was 1.23 per cent that was similar to the ash content after 2 month of storage (1.23 per cent) while the ash content of Wood Apple Mango bar upto 4 month was 1.13 per cent that was similar to the ash content after 3 month of storage and showed non significant difference. The percentage of total ash content of Wood Apple fruit bar (control) after 6 month storage was 1.24 that was similar to the ash content after 5 month storage (1.24 per cent) while the percentage of total ash content of Wood Apple Mango bar after 6 month of storage was 1.14 that was similar to the ash content after 5 month of storage (1.14 per cent). The result showed non significance difference in total ash content of Wood Apple fruit bar (control) and Wood Apple Mango during 6 months of storage. The protein enriched Sapota bar had initial ash content of 2.0 per cent and changed to 1.94 per cent after 6 months of storage was observed by Saravana and Manimegalai (2002). The Mango and banana fruit bar prepared by Mathur *et al.* (1972) contained 0.52 to 0.66g percent ash content. The data was found in conformity with the results observed in the present study.

The calcium content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 169.60 and 156.70 mg/100g. The changes in the calcium content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The initial calcium content of Wood Apple fruit bar (control) and Wood Apple Mango bar was 169.60 and 156.70 mg/100g, respectively. The calcium content of Wood Apple fruit bar (control) after 1 month was 169.60 mg/100g that was similar to the initial value of calcium (169.60 mg/100g) and while the calcium content of Wood Apple Mango bar upto 2 month was 156.70 mg/100g that was similar to the initial value of calcium content (156.70 mg/100g) and showed a non significant difference. The value of calcium content of Wood Apple fruit bar (control) after 3 month was 169.70 mg/100g that was similar to the calcium content after 2 month of storage (169.70 mg/100g) while the calcium content of Wood Apple Mango bar upto 4 month was 156.80 mg/100g that was similar to the calcium content after 3 month of storage (156.80 mg/100g). There were non significant changes during storage. The calcium content of Wood Apple fruit bar (control) upto 6 month was 169.80 mg/100g that was similar to the calcium content

after 4 month of storage (169.80 mg/100g) while the calcium content of Wood Apple Mango bar upto 6 month was 156.90 mg/100g that was similar to the calcium content after 5 month of storage (156.90 mg/100g). The calcium content of Wood Apple fruit bar (control) and Wood Apple Mango bar increased insignificantly from 169.60 and 156.70 mg/100g to 169.80 and 156.90 mg/100g, respectively during 6 month of storage.

The phosphorus content of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 78.00 and 72.40 mg/100g. The changes in the phosphorus content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The phosphorus content of Wood Apple fruit bar (control) after 1 month of storage was 78.00 mg/100g that was similar to the initial value of phosphorus content (78.00 mg/100g) while the phosphorus content of Wood Apple Mango bar upto 2 month was 72.40 mg/100g that was similar to the initial value of phosphorus content (72.40 mg/100g). No appreciable changes were observed during storage. The phosphorus content of Wood Apple fruit bar (control) after 3 month and after 6 month of storage was 78.01 and 78.02 mg/100g respectively. The result showed a non significant difference in the phosphorus content of Wood Apple fruit bar (control). The phosphorus content of Wood Apple Mango bar after 4 month and after 6 month was 72.60 and 72 .80 mg/100g, respectively and showed a non significant difference. The results showed insignificant increment in the phosphorus content of Wood Apple fruit bar (control) and Wood Apple Mango bar during 6 months of storage period.

The total sugar of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 14.25 and 14.72 per cent, respectively. During the storage period the total sugar showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the total sugar of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The initial total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar was 14.25 and 14.72 per cent, respectively, which had decreased to 14.16 and 13.35 per cent after 1 month of storage. The change in the total sugar of bar sample was significantly different ($P \leq 0.05$). The percentage of total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 13.92 and 13.30, respectively. There was significant difference in the total sugar of the product

during the storage period. The percentage of total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 13.45 and 12.56, respectively and showed a significant difference ($P \leq 0.05$). The percentage of total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 12.86 and 11.9, respectively. The results showed regular decline in total sugar. The decline in the total sugar may be due to the utilization by bacteria or conversion of sugar to other products during storage. The difference in the total sugar was significantly different ($P \leq 0.05$). The percentage of total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 12.68 and 11.2, respectively and showed a significant difference ($P \leq 0.05$). The total sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 12.18 and 10.78 per cent from initial total sugar of 14.25 and 14.72 per cent. The change in the total sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.005 and 0.035). The data observed was found to be in conformity with the results reported by Saravana and Manimegalai (2002). He observed that the protein enriched Sapota bar had total sugar 53.40g percent initially, which decreased to 52.12g percent on 6 months of storage. The total sugar in Papaya fruit bar decreased significantly on storage (Aruna *et al.,* 1999).

The reducing sugar of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 4.95 and 5.10 per cent, respectively. A gradual increase in the reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar was observed during storage. The changes in the reducing sugar content of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The initial reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar was 4.95 and 5.10 per cent, respectively, which had increased to 5.08 and 5.28 per cent after 1 month of storage. The change in the reducing sugar of bar sample was significantly different ($P \leq 0.05$). The percentage of reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was increased to 5.44 and 5.40, respectively. There was significant difference ($P \leq 0.05$) in the reducing sugar of the product during the storage period. The percentage of reducing sugar Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was 5.86 and 6.20, respectively and showed significant difference ($P \leq 0.05$). The percentage of reducing sugar in Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.08 and 6.60,

respectively. The results showed regular increment in reducing sugar content. The percentage of reducing sugar was increased due to the conversion of non-reducing sugar to reducing sugar during storage. The difference in the reducing sugar was significantly different (P≤ 0.05). The percentage of reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.53 and 6.68, respectively and showed a significant difference (P≤ 0.05). The reducing sugar content of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was increased to 6.92 and 6.90 per cent from initial reducing sugar content of 4.95 and 5.10 per cent. The change in the total sugar was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.050). The reducing sugar content of the protein enriched Sapota bar increased from 7.25 to 8.30g per cent was reported by Saravana and Manimegalai (2002). A gradual increase in the reducing sugar content of the Mango sheets from 12.73 to 14.92 per cent during 3 months of storage was reported by Rao and Roy (1980). Chauhan *et al.* (1997) observed that the reducing sugar in Mango bar and Mango-soy fruit bar after six months of storage changed from 33.00 to 38.80 and 29.60 to 33.40g per cent, respectively. The results were found in conformity with the results observed in the present study.

The non-reducing sugar of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 9.30 and 9.62 per cent. During the storage period the non-reducing sugar showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the non-reducing sugar of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.12b and 4.13b). The initial non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar was 9.30 and 9.62 per cent, respectively, which had decreased to 9.08 and 8.07 per cent after 1 month of storage. The change in the non-reducing sugar of bar sample was significantly different (P≤ 0.05). The percentage of non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 8.48 and 7.9, respectively. There was significant difference (P≤ 0.05) in the non-reducing sugar of the product during the storage period. The percentage of non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 7.59 and 6.36, respectively and showed a significant difference (P≤ 0.05). The percentage of non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.78 and 5.30, respectively. The results showed regular

decline in non-reducing sugar. The decline in the non-reducing sugar may be due to the conversion of non-reducing sugar to reducing sugar during storage. The difference in the non-reducing sugar was significantly different ($P \leq 0.05$). The percentage of non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.15 and 4.52, respectively and showed a significant difference ($P \leq 0.05$). The non-reducing sugar of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 5.26 and 3.88 per cent from initial non-reducing sugar content of 9.30 and 9.62 per cent. The change in the non-reducing sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.004 and 0.034). Aruna *et al.* 1999 observed that the non reducing sugar in Papaya fruit bar decreased significantly on storage. The results were found in conformity with the results observed in the present study.

Table 4.12a: Changes in chemical constituents of Wood Apple fruit bar (control) during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	17.40	0.48	2.20	78.70	64.34	2.35	3.90	78.90
1 Month	17.20	0.48	2.18	78.92	62.98	2.36	3.86	78.92
2 Month	16.80	0.47	2.16	79.34	60.12	2.38	3.85	78.98
3 Month	16.35	0.46	2.12	79.83	58.86	2.42	3.76	79.02
4 Month	15.76	0.46	2.10	80.44	54.44	2.43	3.70	79.08
5 Month	14.64	0.45	1.98	81.68	52.62	2.45	3.67	79.12
6 Month	13.52	0.45	1.92	82.86	50.18	2.48	3.63	79.16
CD (5%)	0.043	NS	0.006	0.045	0.006	0.006	0.006	0.006
P Value	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.12b: Changes in chemical constituents of Wood Apple fruit bar (control) during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	1.22	169.60	78.00	14.25	4.95	9.30
1 Month	1.22	169.60	78.00	14.16	5.08	9.08
2 Month	1.23	169.70	78.01	13.92	5.44	8.48
3 Month	1.23	169.70	78.01	13.45	5.86	7.59
4 Month	1.24	169.80	78.02	12.86	6.08	6.78
5 Month	1.24	169.80	78.02	12.68	6.53	6.15
6 Month	1.24	169.80	78.02	12.18	6.92	5.26
CD (5%)	NS	NS	NS	0.005	0.006	0.004
P Value	0.08	0.08	0.08	0.00	0.00	0.00

Table 4.13a: Changes in chemical constituents of Wood Apple Mango bar during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	14.80	0.46	1.98	81.64	62.20	2.44	4.32	78.1
1 Month	14.02	0.46	1.96	82.44	60.00	2.45	4.30	78.2
2 Month	13.78	0.45	1.95	82.68	58.72	2.48	4.27	78.4
3 Month	12.88	0.45	1.92	83.61	56.14	2.50	4.23	78.6
4 Month	11.60	0.44	1.90	85.25	52.62	2.51	4.19	78.8
5 Month	11.15	0.44	1.88	85.37	48.06	2.53	4.13	78.8
6 Month	10.95	0.43	1.84	85.62	46.78	2.55	4.07	78.9
CD (5%)	0.035	NS	0.006	0.123	0.025	0.025	0.025	0.061
P Value	0.00	0.13	0.00	0.00	0.00	0.02	0.00	0.00

Table 4.13b: Changes in chemical constituents of Wood Apple Mango bar during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	1.12	156.70	72.40	14.72	5.10	9.62
1 Month	1.12	156.70	72.40	13.35	5.28	8.07
2 Month	1.13	156.70	72.40	13.30	5.40	7.90
3 Month	1.13	156.80	72.50	12.56	6.20	6.36
4 Month	1.13	156.80	72.50	11.90	6.60	5.30
5 Month	1.14	156.90	72.60	11.20	6.68	4.52
6 Month	1.14	156.90	72.60	10.78	6.90	3.88
CD (5%)	NS	NS	NS	0.035	0.050	0.034
P Value	0.13	0.08	0.08	0.00	0.00	0.00

4.2.2.2 *Organoleptic evaluation*

Sensory evaluation is a scientific method used to measure analyze and interpret responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Stone and Sidel, 1993). The acceptability of blended Wood Apple bar was evaluated by using ten member panel as per the standard procedure. The value of the scores of sensory evaluation is a tool for the evaluation of the quality of the product developed. This tool depends on the objectivity, precision and reproductively of the judgment of the panelists (Pal *et al.*, 1995). The sensory evaluation of bar samples were taken on a 9 point hedonic scale (Appendix I), from panel members, on the different quality parameters (colour, flavour, taste, body and texture, chewness and overall acceptability). The sensory receptors did not perceive any unfavorable change in quality throughout the storage. The data of the same was analysed to test the significance between the products (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

4.2.2.2.1 *Changes in the organoleptic qualities during storage*

The final product was stored for the determination of storage quality. The effect of storage on the organoleptic qualities of fruit bar was assessed during a storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15).

The score for colour of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.85 and 8.35, respectively. During the storage period the colour score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the colour score of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for colour of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.85 and 8.35, respectively, which had decreased to 7.70 and 8.25 after 1 month of storage. The change in the colour score of bar samples was non significantly different. The sensory score for colour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.20 and 8.05, respectively. There was significant difference ($P \leq 0.05$) in the colour score of the product during the storage period. The

sensory score for colour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 6.95 and 7.75, respectively and showed a significant difference (P≤ 0.05). The sensory score for colour of Wood Apple fruit bar (control) after 4 month storage was decreased to 6.85 and showed regular decline in colour score while the sensory score for colour of Wood Apple Mango bar upto 4 month was 7.75 and showed no appreciable change in the colour. The difference in the colour score was significantly different (P≤ 0.05). The sensory score for colour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.65 and 7.75, respectively and showed a significant difference (P≤ 0.05). The colour score of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 6.6 and 7.2 from initial colour score of 7.85 and 8.35. The results showed the change in the colour score was significant at 5 percent level of significance (CD = 0.255 and 0.223) but the product was acceptable after the 6 month storage.

The score for flavour of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.75 and 8.25, respectively. During the storage period the colour score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the colour score of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for flavour of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.75 and 8.25, respectively, which had decreased to 7.70 and 7.65 after 1 month of storage. The change in the flavour score of bar sample was significantly different (P≤ 0.05). The sensory score for flavour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.10 and 7.55, respectively. There was significant difference (P≤ 0.05) in the flavour score of the product during the storage period. The sensory score for flavour of Wood Apple fruit bar (control) after 3 month storage was decreased to 7.00 and showed a significant difference (P≤ 0.05) while the flavour score of Wood Apple Mango bar upto 3 month was 7.55 that was similar to the flavour score after 2 month (7.55) and showed no appreciable change in the colour. The sensory score for flavour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.90 and 7.50, respectively. The difference in the flavour score

was significantly different (P≤ 0.05). The sensory score for flavour of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.65 and 7.35, respectively and showed a significant difference (P≤ 0.05). The sensory score for flavour of Wood Apple fruit bar (control) after 6 month storage was decreased to 6.35 while the sensory score for flavour of Wood Apple Mango bar upto 6 month was 7.35. There was no appreciable change in the flavour. The results showed the change in the flavour score was significant at 5 percent level of significance (CD = 0.242 and 0.188) but the product was acceptable after the 6 month storage.

The score for taste of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.65 and 8.30, respectively. During the storage period the taste score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the taste score of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for taste of Wood Apple fruit bar (control) was 7.65 which had decreased to 7.55 after 1 month storage and showed non significant difference while the initial score for taste of Wood Apple Mango bar was 8.30 which had decreased to 7.99 after 1 month of storage and showed significant change (P≤ 0.05). The sensory score for taste of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.15 and 7.75, respectively. There was significant difference (P≤ 0.05) in the taste score of the product during the storage period. The sensory score for taste of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 7.00 and 7.35, respectively and showed a significant difference (P≤ 0.05). The sensory score for taste of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.90 and 7.30, respectively. The difference in the taste score was significantly different (P≤ 0.05). The sensory score for taste of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.55 and 7.15, respectively and showed a significant difference (P≤ 0.05). The taste score of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 6.05 and 7.10 from initial taste score of 7.65 and 8.30. The results showed the change in the taste score was

significant at 5 percent level of significance (CD = 0.279 and 0.213) and the product was acceptable after the 6 month storage.

The score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.95 and 8.43, respectively. During the storage period the taste score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the taste score of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.95 and 8.43, respectively, which had decreased to 7.65 and 7.75 after 1 month of storage. The change in the body and texture score of bar sample was significantly different ($P \leq 0.05$). The sensory score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.15 and 7.65, respectively. There was significant difference ($P \leq 0.05$) in the body and texture score of the product during the storage period. The sensory score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 6.90 and 7.50, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.85 and 7.35, respectively. The results showed regular decline in body and texture score. The difference in the body and texture score was significantly different ($P \leq 0.05$). The sensory score for body and texture of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.60 and 7.30, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for body and texture of Wood Apple fruit bar (control) after 6 month storage was decreased to 6.45 and showed a significant difference while the sensory score for body and texture of Wood Apple Mango bar upto 6 month was 7.30 that was similar to the body and texture score after 5 month storage (7.30) and showed non significant difference. The results showed the change in the body and texture score was significant at 5 percent level of significance (CD = 0.238 and 0.185) but the product was acceptable ever after the 6 month storage.

The score for chewness of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.75 and 8.40, respectively. During the storage period the chewness score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the chewness score of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for chewness of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.75 and 8.40, respectively, which had decreased to 7.50 and 8.0 after 1 month of storage. The change in the chewness score of bar sample was significantly different ($P \leq 0.05$). The sensory score for chewness of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.15 and 7.65, respectively. There was significant difference ($P \leq 0.05$) in the chewness score of the product during the storage period. The sensory score for chewness of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 7.00 and 7.60, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for chewness of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.85 and 7.50, respectively. The decline in the chewness score may be due to the softness of the bar with time during storage. The difference in the chewness score was significantly different ($P \leq 0.05$). The sensory score for chewness of Wood Apple fruit bar (control) after 5 month storage was decreased to 6.45 and showed significant change ($P \leq 0.05$) while the sensory score for chewness of Wood Apple Mango bar upto 5 month was 7.50 and that was similar to the chewness score after 4 month storage (7.50) and showed a non significant change. The chewness score of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 5.80 and 7.40, respectively from initial chewness score of 7.75 and 8.40. The results showed the change in the chewness score was significant at 5 percent level of significance (CD = 0.255 and 0.190) but the product was acceptable ever after the 6 month storage.

The score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 7.79 and 8.29, respectively. During the storage period the overall acceptability score showed a declining trend in Wood Apple fruit bar (control) and Wood Apple Mango bar. The changes in the overall acceptability score of bar

samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.14 and 4.15). The initial sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.79 and 8.29, respectively, which had decreased to 7.59 and 7.92 after 1 month of storage. The change in the overall acceptability score of bar sample was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 7.15 and 7.73, respectively. There was significant difference ($P \leq 0.05$) in the overall acceptability score of the product during the storage period. The sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 6.97 and 7.55, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 6.87 and 7.48, respectively. The decline in the overall acceptability score may be due to the decrease in quality parameters with time. The difference in the overall acceptability score was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 6.58 and 7.33, respectively and showed a significant difference ($P \leq 0.05$). The overall acceptability score of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 months of storage was decreased to 6.25 and 7.27 from initial overall acceptability score of 7.79 and 8.29, respectively. The results showed the change in the overall acceptability score was significant at 5 percent level of significance (CD = 0.209 and 0.156) but the product was acceptable after the 6 month storage.

4.2.2.3 *Textural analysis*

The textural characteristics of the bar were determined to evaluate the changes in the stickiness/adhesiveness and hardness of the bar. These parameters will give an idea about the chewing characteristics of the bar. The adhesiveness of the Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was -0.108 and -0.110 kg, respectively. A gradual increase in the adhesiveness of Wood Apple fruit bar (control) and Wood Apple Mango bar was observed during storage.

Table 4.14: Changes in sensory attributes in Wood Apple fruit bar (control) during storage

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
0 Day	7.85	7.75	7.65	7.95	7.75	7.79
1 Month	7.70	7.55	7.55	7.65	7.50	7.59
2 Month	7.20	7.10	7.15	7.15	7.15	7.15
3 Month	6.95	7.00	7.00	6.90	7.00	6.97
4 Month	6.85	6.90	6.90	6.85	6.85	6.87
5 Month	6.65	6.65	6.55	6.60	6.45	6.58
6 Month	6.60	6.35	6.05	6.45	5.80	6.25
CD (5%)	0.255	0.242	0.279	0.238	0.225	0.209
P Value	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.15: Changes in sensory attributes in Wood Apple Mango bar during storage

Treatment	Colour	Flavour	Taste	Body & Texture	Chewness	Overall Acceptability
0 Day	8.35	8.25	8.30	8.43	8.40	8.29
1 Month	8.25	7.65	7.99	7.75	8.00	7.92
2 Month	8.05	7.55	7.75	7.65	7.65	7.73
3 Month	7.75	7.55	7.35	7.50	7.60	7.55
4 Month	7.75	7.50	7.30	7.35	7.50	7.48
5 Month	7.35	7.35	7.15	7.30	7.50	7.33
6 Month	7.20	7.35	7.10	7.30	7.40	7.27
CD (5%)	0.223	0.188	0.213	0.185	0.190	0.156
P Value	0.00	0.03	0.00	0.00	0.00	0.00

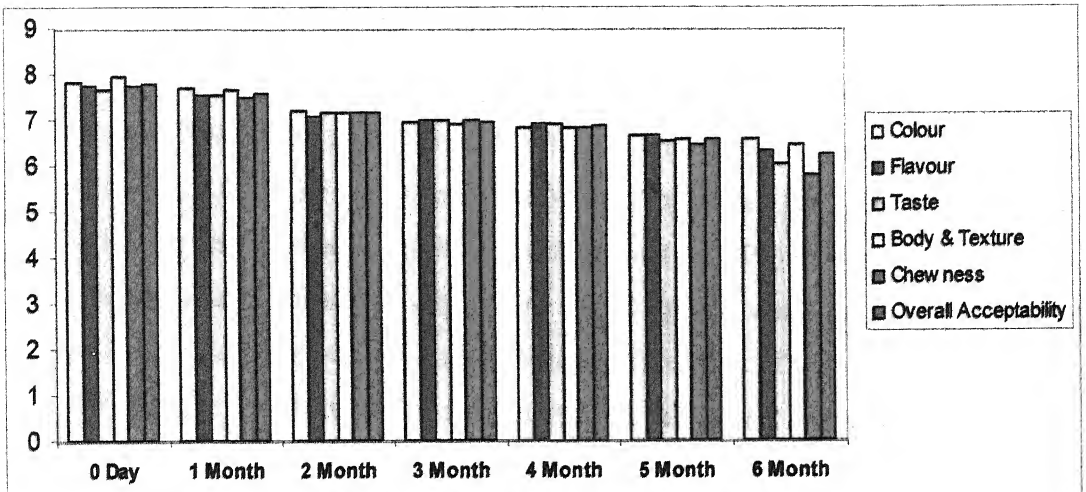


Fig. 4.6: Changes in sensory attributes in Wood Apple fruit bar (control) during storage

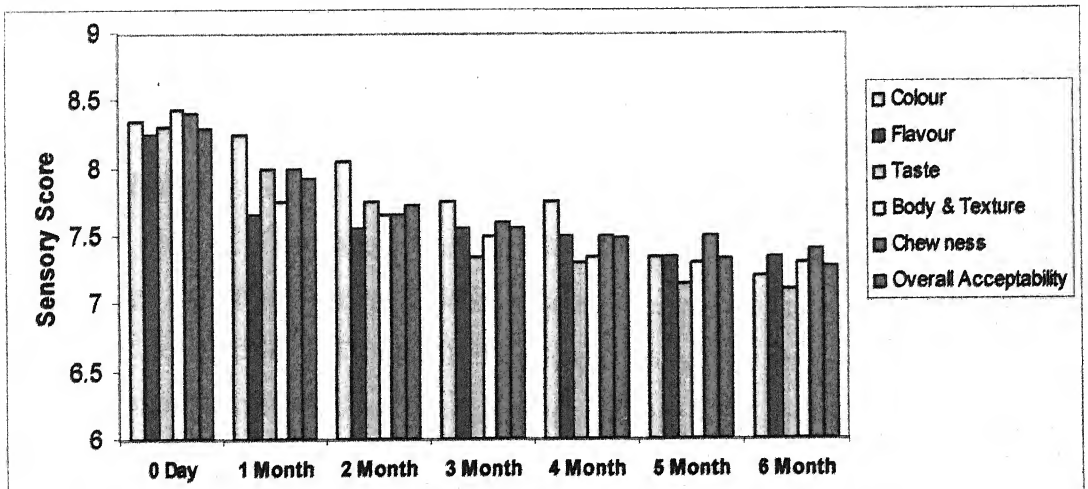


Fig. 4.7: Changes in sensory attributes in Wood Apple mango bar during storage

The changes in the adhesiveness of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.16). The adhesiveness of Wood Apple fruit bar (control) upto 1 month was -0.108 kg and showed non significant difference ($P \leq 0.05$) while the initial adhesiveness of Wood Apple Mango bar was -0.110g which had increased to -0.112 kg after 1 month of storage and showed significant difference ($P \leq 0.05$). The adhesiveness of Wood Apple fruit bar (control) after 2 month was -0.109 kg and showed a significant difference ($P \leq 0.05$) while the adhesiveness of Wood Apple Mango bar upto 2 month was -0.112 kg that was similar to the 1 month of storage (-0.112 kg) and shown non significant difference. The adhesiveness of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was -0.110 and -0.113 kg, respectively and showed a significant difference ($P \leq 0.05$). The adhesiveness of Wood Apple fruit bar (control) upto 4 month was -0.110 kg that was similar to the 3 month of storage (-0.110 kg) and showed non significant difference while the adhesiveness of Wood Apple Mango bar after 4 month storage was -0.114 kg and showed significant different ($P \leq 0.05$). The results showed regular increment in adhesiveness. The percentage of adhesiveness was increased due to the presence of sugar and increase in the concentration of invert sugar and reducing sugar during storage. The difference in the adhesiveness was significantly different ($P \leq 0.05$). The adhesiveness of Wood Apple fruit bar (control) after 5 month was -0.112 kg and showed a significantly different ($P \leq 0.05$) while the adhesiveness of Wood Apple Mango bar upto 5 month was -0.114 kg that was similar to the 4 month of storage (-0.114 kg) and showed no appreciable change. The adhesiveness of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 month of storage was increased to -0.114 and -0.116 kg from initial adhesiveness of -0.108 and -0.110 kg, respectively. The change in the adhesiveness was significant at 5 per cent level of significance (CD = 0.001 and 0.001) but the product was acceptable after the 6 month storage.

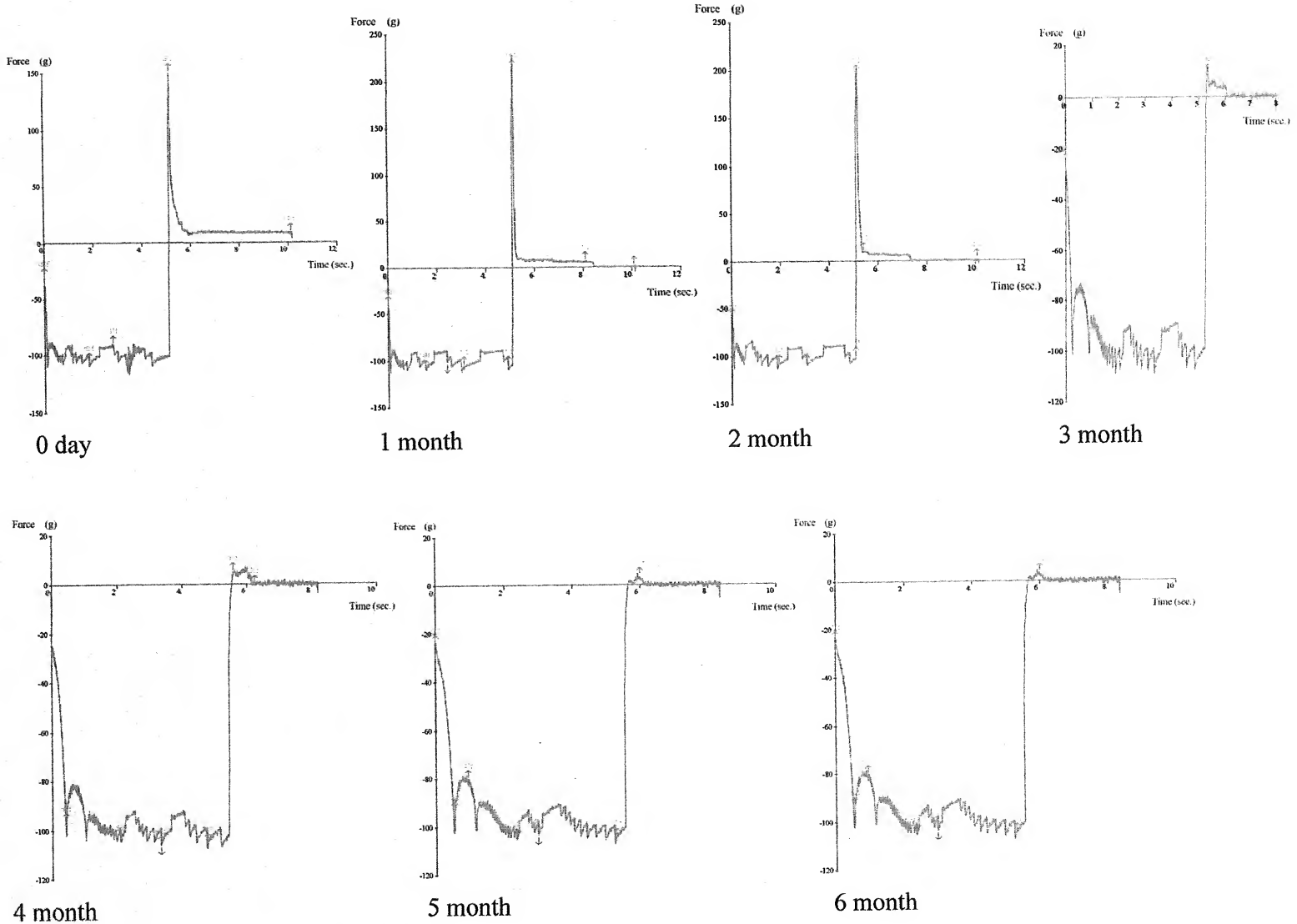


Fig. 4.8: Adhesiveness of wood apple fruit bar during storage

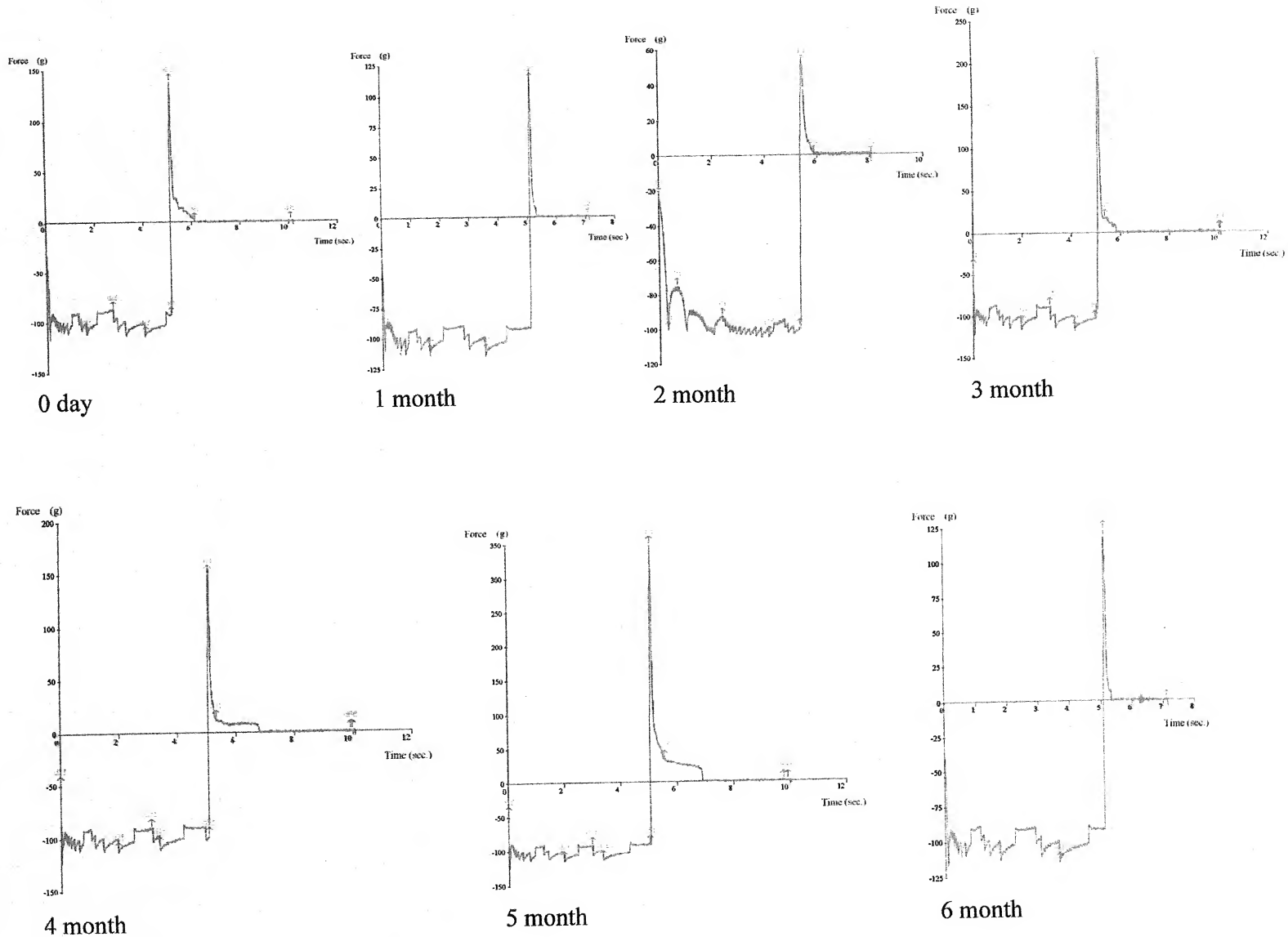
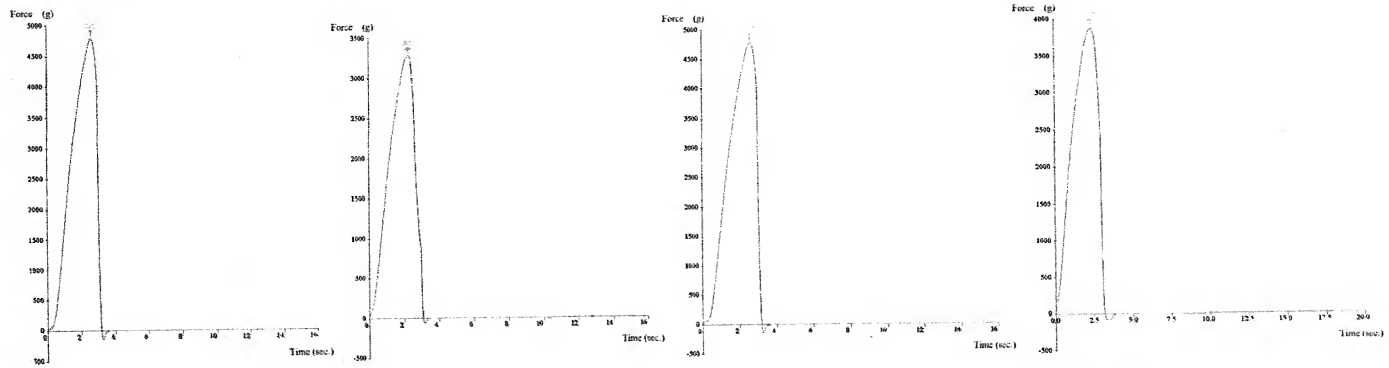
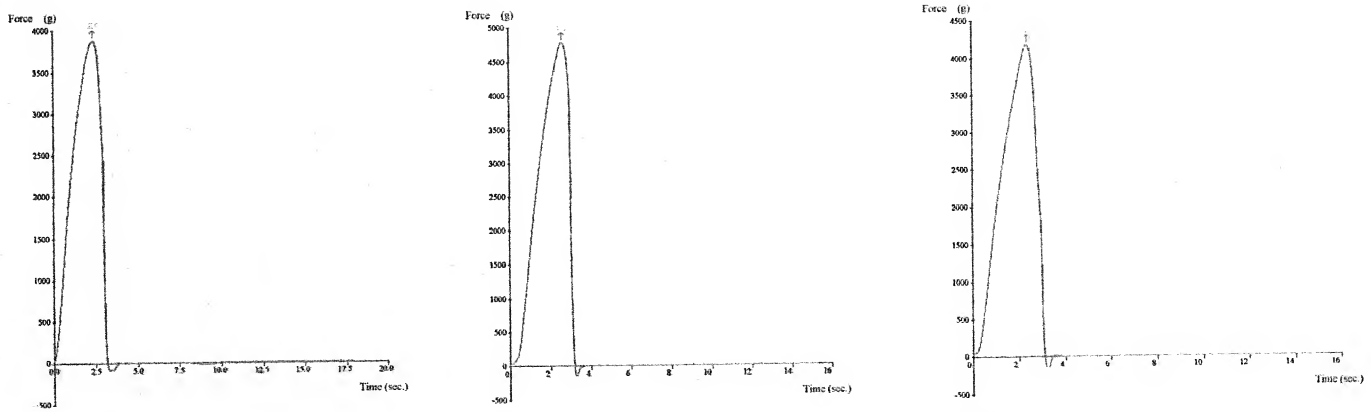


Fig. 4.9: Adhesiveness of wood apple mango bar during storage

The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar on zero day was 2.80 and 3.04 kg, respectively. A gradual increase in the cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar was observed during storage. The changes in the cutting strength of bar samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.16). The initial sensory score for cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar was 2.80 and 3.04 kg, respectively, which had decreased to 2.57 and 2.80 kg after 1 month of storage. The change in the cutting strength of bar sample was significantly different ($P \leq 0.05$). The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar after 2 month was decreased to 2.52 and 2.68 kg, respectively. There was significant difference ($P \leq 0.05$) in the cutting strength score of the product during the storage period. The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar after 3 month storage was decreased to 2.47 and 2.36 kg, respectively and showed a significant difference ($P \leq 0.05$). The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar after 4 month storage was 2.43 and 2.33 kg, respectively. The results showed regular decline in cutting strength. The cutting strength was decreased due to the presence of sugar and increase in the concentration of invert sugar and reducing sugar during storage. The difference in the cutting strength was significantly different ($P \leq 0.05$). The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar after 5 month of storage was 2.36 and 2.16 kg, respectively and showed a significant difference ($P \leq 0.05$). The cutting strength of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 month of storage was decreased to 2.16 and 2.12 kg from initial cutting strength of 2.80 and 3.04 kg. The results showed the change in the cutting strength was significant at 5 per cent level of significance (CD = 0.110 and 0.113) but the product was acceptable after the 6 month storage.

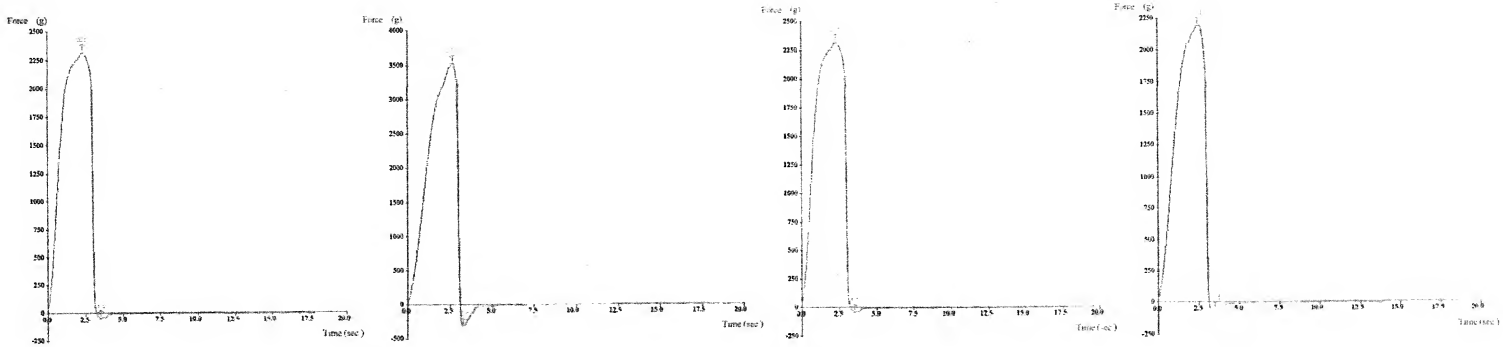


0day 1 month 2 month 3 month

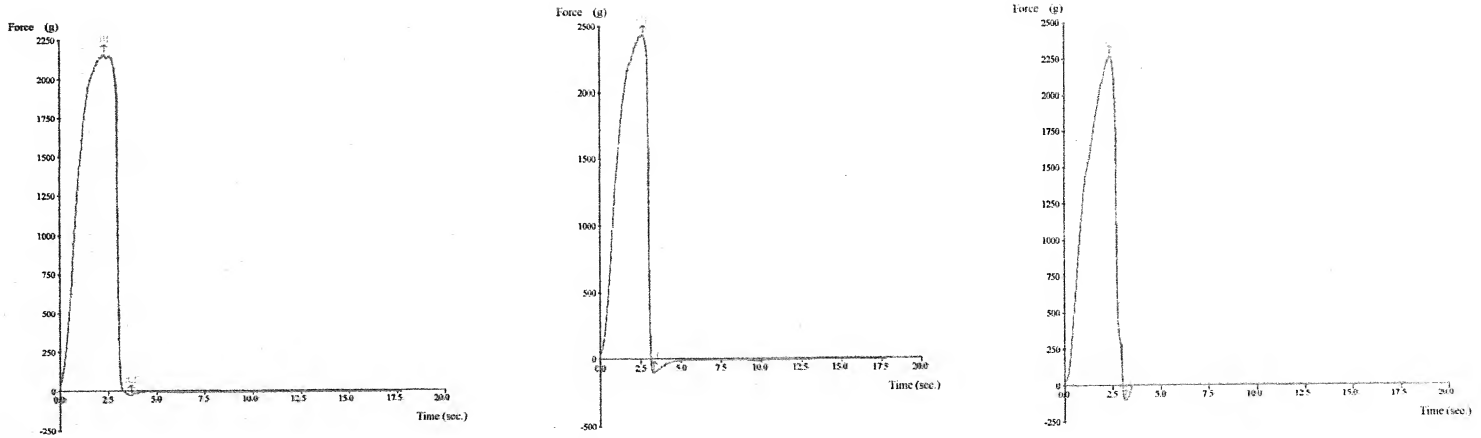


4 month 5 month 6 month

Fig. 4.10: Cuttingness of wood apple fruit bar during storage



0 day 1 month 2 month 3 month



4 month 5 month 6 month

Fig. 4.11: Cutningness of wood apple mango bar during storage

Table 4.16: Changes in texture of bar samples during storage

Treatments	Adhesiveness (kg)		Cuttingness (kg)	
	Wood Apple Fruit bar(Control)	Wood Apple Mango Bar	Wood Apple Fruit bar(Control)	Wood Apple Mango Bar
0 Days	-0.108	-0.110	2.80	3.04
1 Month	-0.108	-0.112	2.57	2.80
2 Month	-0.109	-0.112	2.52	2.68
3 Month	-0.110	-0.113	2.47	2.36
4 Month	-0.110	-0.114	2.43	2.33
5 Month	-0.112	-0.114	2.36	2.16
6 Month	-0.114	-0.116	2.16	2.12
CD (5%)	0.001	0.001	0.11	0.113
P Value	0.01	0.00	0.01	0.00

4.2.2.4 *Microbiological analysis*

Microbial food safety is an essential component of food quality. Quality is a combination of characteristics that have significance in determining the degree of acceptability of the product to a consumer. The microbial quality of the Wood Apple bar samples was observed periodically. Microbiological changes were evaluated at the interval of 0, 1, 2, 3, 4, 5 and 6 months during storage at room temperature (16-35°C).

The total plate count was nil at initial stage of storage. The effect of storage on the quality of fruit bar was assessed during the storage period of 6 months with an interval of 1 month (Table 4.17). Total plate counts were not observed upto 3 months of storage. The total plate count of Wood Apple fruit bar (control) and Wood Apple Mango bar after 6 month of storage was 5.0×10^2 and 7.0×10^2 cfu/g, respectively. Yeast and mould counts in Wood Apple fruit bar (control) and Wood Apple Mango bar were nil at initial days of storage. Yeast and mould counts were not recorded upto 3 months storage while after 6 months the yeast and mould count were 1.0×10^2 and 1.5×10^2 cfu/g, respectively at room temperature. Coliform count was found to be nil throughout the storage period. This indicated that the product remained safe microbiologically during storage and acceptable after 6 months of storage and no appreciable change was observed. Cherian and Cheriyan (2003) reported that the standardised Papaya fruit bar with 0.5 per cent citric aid and 0.3 per cent potassium metabisulphite and dried to 15 per cent moisture remained preserved for eight months. Saravana and Manimegalai (2002) observed that the microbial analysis in sapota fruit bar indicated the presence of 6×10^{-6}cfu/g bacteria, 4×10^{-4}cfu/g fungi and 4×10^{-5}cfu/g yeast, respectively. Veeranan *et al.* (2005) reported that the bacterial content in mix fruit bar 50: 50 ratio (Mango: banana) was increased during the storage period. The initial bacterial load in mix fruit bar was 1.0×10^3 and after the storage period of 5 months it was 3.0×10^3cfu/g. Manimegalai (2001) reported that the jack fruit bar samples packed in MPP (Metallised Polyester low density Polyethylene laminate) pouches showed minimum of microbial counts than samples packed in PP pouches (Polypropylene Pouches) and BP (Butter Paper) after 180 days of storage. According to Aruna *et al.* (1999), no microbial count was noticed upto 3 months storage but after 6 months storage, yeast and mould counts were observed and these increased further 9 months storage. The increase in microbial count was proportionate to storage temperature. The periodical testing of microbial count in Papaya- Mango blended leather on storage revealed complete absence of any contaminated microorganism

upto 8 months storage period (CFTRI, 1887). The data was found in conformity with the results observed in the present study.

Table 4.17: Microbial count in Wood Apple bar samples during storage

Treatments	Total Plate Count		Yeast & Mould Count	
	Wood Apple Fruit Bar (Control)	Wood Apple Mango Bar	Wood Apple Fruit Bar (Control)	Wood Apple Mango Bar
0 days	0	0	0	0
1 Month	0	0	0	0
2 Month	0	0	0	0
3 Month	0	0	0	0
4 Month	1.0×10^1	2.0×10^1	1.0×10^1	1.0×10^1
5 Month	2.0×10^2	4.0×10^2	2.0×10^1	2.0×10^1
6 Month	5.0×10^2	7.0×10^2	1.0×10^2	1.5×10^2
CD (5%)	0.435	0.503	0.435	0.435
P value	0.00	0.00	0.01	0.00

4.3 PREPARATION OF THE WOOD APPLE NECTAR

4.3.1 Standardization of the Parameters

4.3.1.1 *Standardization of Wood Apple pulp percentage*

Wood Apple pulp was used for the preparation of nectar. The nectar was prepared by standard method. The percentage of Wood Apple pulp in the nectar was standardized by incorporation of 20, 25 and 30 per cent pulp (Table 4.18). The sensory score for 20, 25 and 30 per cent Wood Apple pulp in nectar was 6.76, 7.58 and 6.46, respectively. The nectar made of 20 per cent pulp was found best with highest score (7.58) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.007). The best score for 20 per cent Wood Apple pulp was due to the more acceptable colour and taste. The colour of the 30 per cent pulp was dark and the nectar was more acidic in nature. The taste of 10 per cent pulp in nectar was very low due to low concentration of Wood Apple pulp.

4.3.1.2 *Standardization of sugar percentage*

Sugar content was standardized by incorporation of 5, 10, 15 and 20 per cent sugar (Table 4.19). The sensory score for 5, 10, 15 and 20 per cent sugar was 5.61, 6.20, 7.83 and 6.85, respectively. The sensory score for 15 per cent sugar was found highest (7.83) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.609). The best score for 15 per cent sugar was due to low sweetness of 5 and10 per cent sugar while very high sweetness for 20 per cent sugar content. The sugar content of 15 per cent was selected for further study.

4.3.1.3 *Standardization of citric acid percentage*

The percentage of citric acid in the nectar was standardized by incorporation of 0.15, 0.25, 0.50 and 1.0 per cent citric acid (Table 4.20). The sensory score for 0.15, 0.25, 0.50 and 1.0 per cent citric acid in nectar was 6.53, 7.48, 6.00 and 5.55, respectively. The nectar made from 0.25 per cent citric acid was found highest score (7.48) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.315). The best score for 0.25 per cent citric acid was due to low acidic taste of 0.15 per cent citric acid while very high acidic in taste for 0.50 and 1.0 per cent citric acid. The taste of 0.25 per cent was more acceptable in comparison to 0.15 per cent due to more palatability. The citric acid of 0.25 per cent was selected for further study.

Table 4.18: Standardization of the percentage of Wood Apple pulp in wood apple nectar

Treatment	Colour	Flavour	Taste	Overall Acceptability
WAP(20%)	6.70	6.80	6.80	6.76
WAP(25%)	7.60	7.50	7.66	7.58
WAP(30%)	6.40	6.40	6.60	6.46
CD (5%)	0.543	0.331	0.345	0.335
P value	0.04	0.00	0.0	0.00

Table 4.19: Standardization of the percentage of sugar in Wood Apple nectar

Treatment	Colour	Flavour	Taste	Overall Acceptability
Sugar (5%)	5.90	5.75	5.20	5.61
Sugar (10%)	6.60	6.25	5.75	6.20
Sugar (15%)	7.70	7.60	8.20	7.83
Sugar (20%)	7.30	6.70	6.55	6.85
CD (5%)	0.648	0.638	0.634	0.609
Probability	0.07	0.06	0.00	0.01

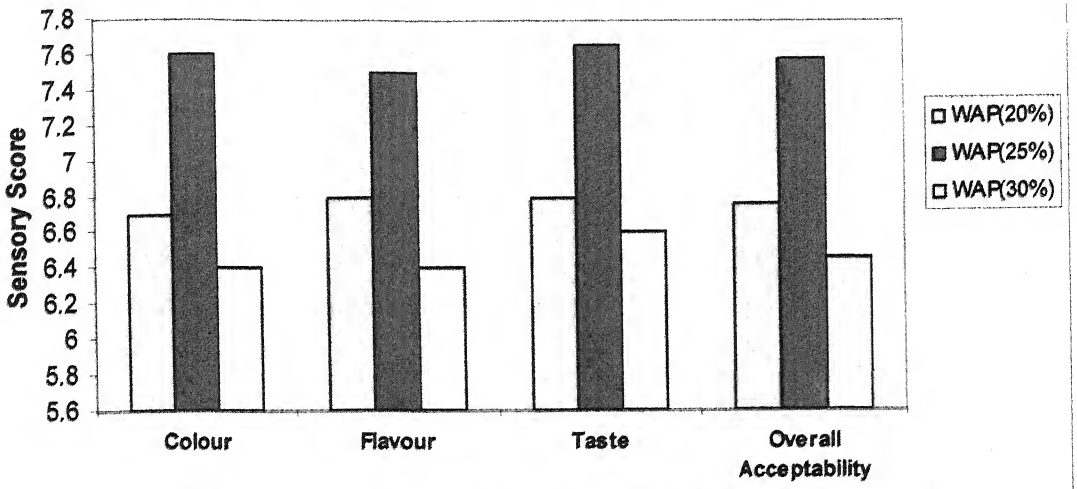


Fig. 4.12: Standardization of the percentage of Wood Apple pulp in Wood Apple nectar

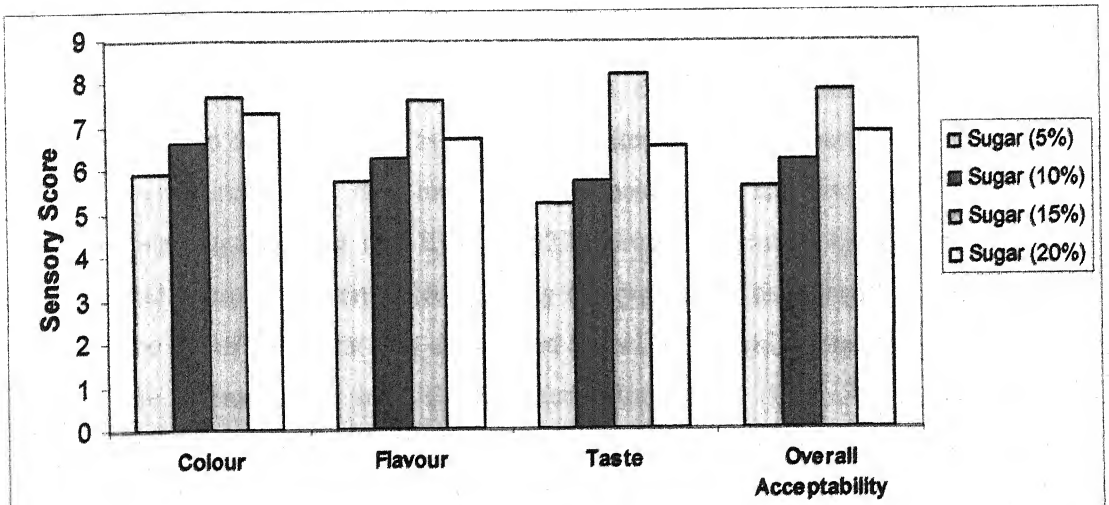


Fig. 4.13: Standardization of the percentage of sugar in Wood Apple nectar

4.3.1.4 *Standardization of KMS percentage*

The percentage of potassium metabisulphite KMS was standardized by incorporation of 0.01, 0.03, and 0.05 per cent KMS (Table 4.21). The sensory score for 0.01, 0.03, and 0.05 per cent KMS in nectar was 7.25, 7.81 and 5.26 respectively. The sensory score for 0.03 per cent KMS was found highest (7.81) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.325). The 0.05 per cent KMS gives unpleasant taste and flavour due to the higher percentage of preservative. The nectar prepared with KMS of 0.03 per cent has good taste and flavour and was selected for further study.

4.3.2 Storage Study

The Wood Apple nectar was stored for the storage study. The Wood Apple nectar was filled in sterilized glass bottles and stored at refrigeration temperature (2-5°C) for 90 days. Physico-chemical characteristics were evaluated at an interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature and physico-chemical, organoleptic, and microbiological changes were observed.

4.3.2.1 *Physico-chemical characteristics*

The chemical constituents present in Wood Apple fruit influence the nutritional and storage qualities of the product. The Wood Apple nectar was analysed for proximate composition as per the approved methods. Moisture content was analysed by oven drying method, ascorbic acid content by titration method using 2, 6, dichlorophenol indophenol dye, total ash, total acidity (as anhydrous citric acid), carbohydrate, sugars (Lane and Eynon, 1923), protein by micro-kjeldahl method, calcium and phosphorus were determined by the procedures described by Ranganna (2003). The pH of the nectar was determined by pH meter while total soluble solids (TSS) were determined by hand Refractometer (Ranganna, 1986). All constituents were analysed at 0, 15, 30, 45, 60, 75 and 90 days of storage at refrigeration temperature (2-5°C).

4.3.2.1.1 *Physico-chemical changes*

The nectar was stored for 90 days and the changes in moisture, protein, ascorbic acid, acidity, pH, TSS, ash, sugars and minerals were observed. The results of the observations are presented in Table 4.22.

Table 4.20: Standardization of the percentage of citric acid in Wood Apple nectar

Treatment	Colour	Flavour	Taste	Overall Acceptability
CA (0.15%)	6.70	6.45	6.45	6.53
CA (0.25%)	7.50	7.30	7.65	7.48
CA (0.50%)	6.20	5.95	5.85	6.00
CA (1.0%)	5.90	5.45	5.30	5.55
CD (5%)	0.333	0.384	0.288	0.315
Probability	0.00	0.00	0.00	0.00

Table 4.21: Standardization of the percentage of preservative (KMS) in wood apple nectar

Treatment	Colour	Flavour	Taste	Overall Acceptability
KMS (0.01%)	7.35	7.35	7.05	7.25
KMS (0.03%)	7.80	7.65	8.00	7.81
KMS (0.05%)	5.93	5.75	5.60	5.76
CD (5%)	0.432	0.342	0.426	0.325
Probability	0.00	0.00	0.00	0.00

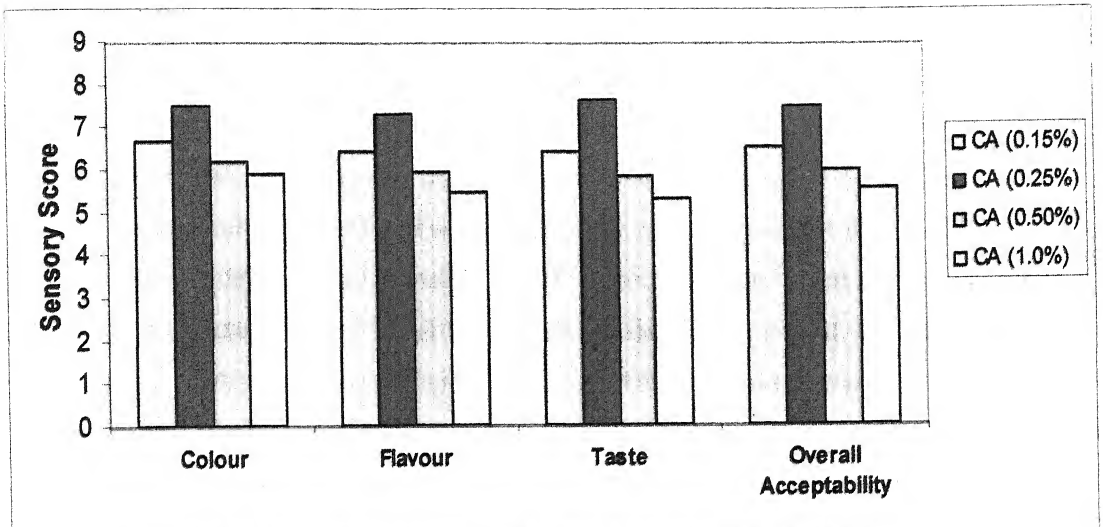


Fig. 4.14: Standardization of the percentage of citric acid in Wood Apple nectar

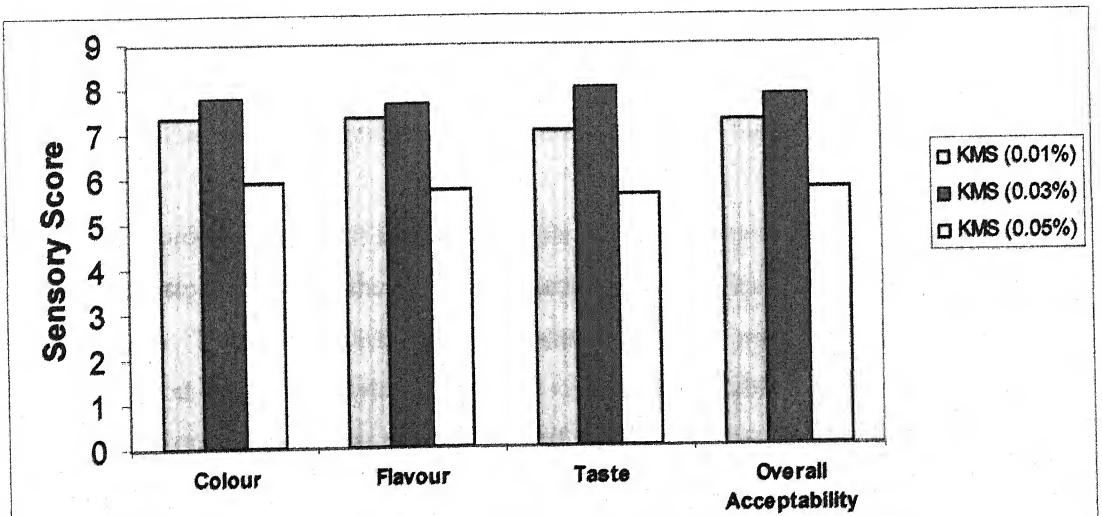


Fig. 4.15: Standardization of the percentage of preservative (KMS) in Wood Apple nectar

The moisture content of the Wood Apple nectar on zero day was 83.78 per cent. During the storage period the moisture content showed a declining trend in Wood Apple nectar. The change in the moisture content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The moisture content of Wood Apple nectar upto 15 days of storage was 83.78 per cent that was similar to the moisture content at zero day (83.78 per cent). There was non significant change in the moisture content. The percentage of moisture content of Wood Apple nectar after 30 days was decreased to 83.76. There was significant difference ($P \leq 0.05$) in the moisture content of the product during the storage period. The percentage of moisture content of Wood Apple nectar after 45 days storage was decreased to 83.70 and showed a significant difference ($P \leq 0.05$). The percentage of moisture content of Wood Apple nectar after 60 days storage was 83.62. The results showed regular decline in moisture content. The decline in the moisture content may be due to the evaporation of moisture from nectar during storage. The difference in the moisture content was significantly different ($P \leq 0.05$). The percentage of moisture content of Wood Apple nectar after 75 days of storage was 83.54 and showed a significant difference ($P \leq 0.05$). The moisture content of Wood Apple nectar after 90 days of storage was decreased to 83.45 per cent from initial moisture content of 83.78 per cent. The change in the moisture content was highly significant ($P = 0.000$) at 5 per cent level of significance (CD = 0.006). Aruna et al., (1997) reported that the moisture content was decreased from 82.02 to 78.98 per cent during 9 months of storage. The results were found in conformity with the results observed in the present study.

The protein content of the Wood Apple nectar on zero day was 0.86 per cent. During the storage period the protein content showed a declining trend in Wood Apple nectar. The change in the protein content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The protein content of Wood Apple nectar after 15 days of storage was decreased to 0.80 per cent from initial protein content of 0.86 per cent. The change in the protein content of nectar was significantly different ($P \leq 0.05$). The percentage of protein content of Wood Apple nectar after 30 days was 0.78. There was significant difference ($P \leq 0.05$) in the protein content of the product during the storage period. The percentage of protein content of Wood Apple nectar after 45 days storage was decreased to 0.74 and showed a significant difference ($P \leq 0.05$). The percentage of protein content of Wood Apple nectar after 60 days storage was 0.72. The results showed regular decline in

protein content. The difference in the protein content was significantly different (P≤ 0.05). The percentage of protein content of Wood Apple nectar after 75 days of storage was 0.69 and showed a significant difference (P≤ 0.05). The protein content of Wood Apple nectar after 90 days of storage was decreased to 0.65 per cent from initial protein content of 0.86 per cent. The change in the protein content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006).

The ascorbic acid content of the Wood Apple nectar on zero day was 37.50 mg/100g. During the storage period the ascorbic acid content showed a declining trend in Wood Apple nectar. The change in the ascorbic acid content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The ascorbic acid content of Wood Apple nectar after 15 days of storage was decreased to 36.70 mg/100g from initial ascorbic acid content of 37.50 mg/100g. The change in the ascorbic acid content of nectar was significantly different (P≤ 0.05). The value of ascorbic acid content of Wood Apple nectar after 30 days was 34.78 mg/100g. There was significant difference (P≤ 0.05) in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of Wood Apple nectar after 45 days storage was decreased to 31.90 mg/100g and showed a significant difference (P≤ 0.05). The value of ascorbic acid content of Wood Apple nectar after 60 days storage was 30.28 mg/100g. The results showed regular decline in ascorbic acid content. The decline in the ascorbic acid content may be due to the depletion of ascorbic acid during storage. The difference in the ascorbic acid content was significantly different (P≤ 0.05). The value of ascorbic acid content of Wood Apple nectar after 75 days of storage was 27.86 and showed a significant difference (P≤ 0.05). The ascorbic acid content of Wood Apple nectar after 90 days of storage was decreased to 26.53 mg/100g from initial ascorbic acid content of 37.50 mg/100g. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.043). A study on the blended nectar prepared by mixing Mango pulps of Totapuri, Banganapalli, Dashehari and Chausa with Papaya pulp showed 50 percent decrease in ascorbic acid content during storage (Kalra *et al.* 1991). Aruna *et al.* 1997 reported that ascorbic acid content was decreased from 8.57 to 4.98 mg/100gm in Papaya nectar during 9 month storage period while in Guava nectar ascorbic acid content was decreased from 54.60 to 32.23 mg/100g during 12 months of storage (Khurdiya and Sagar, 1991). The results were found in conformity with the results observed in the present study.

The acidity of the Wood Apple nectar on zero day was 0.53 per cent. No appreciable change in the acidity of Wood Apple nectar was observed during the storage. The change in the acidity of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The acidity of Wood Apple nectar upto 30 days of storage was 0.53 per cent that was similar to the acidity at zero day (0.53 per cent). There was non significant change in the acidity. The percentage of acidity of Wood Apple nectar after 45 and 60 days of storage was 0.54. There was slight increment of acidity in Wood Apple nectar after 45 days and showed significant change ($P \leq 0.05$). The slight change in the acidity might be due to the concentration of the product due to evaporation of the moisture during storage. The percentage of acidity of Wood Apple nectar after 75 days and 90 days of storage was 0.55. The change in the acidity was significantly different ($P \leq 0.05$). Aruna et al. (1997) reported the non significant changes in the acidity of Papaya nectar during 9 month storage while acidity content was increased from 0.42 to 0.45 in protein-rich Mango beverage during 10 months storage and showed non significant changes (Chauhan *et al.*, 1998). The results were found in conformity with the results observed in the present study.

The pH of the Wood Apple nectar on zero day was 3.35. During the storage period the pH showed a declining trend in Wood Apple nectar. The change in the pH content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The pH of Wood Apple nectar after 15 days of storage was 3.35 that was similar to the pH at zero day (3.35). There was non significant change in the pH. The value of pH of Wood Apple nectar after 30 days was decreased to 3.33 and showed a non significant change. The value of pH of Wood Apple nectar after 45 days storage was decreased to 3.30. Wood Apple nectar showed a non significant difference from zero day (3.35) to 45 days (3.30). The value of pH of Wood Apple nectar after 60 days storage was 3.28. The results showed regular decline in pH. The difference in the pH was significantly different ($P \leq 0.05$). The value of pH of Wood Apple nectar after 75 days of storage was 3.22 and showed a significant difference ($P \leq 0.05$). The pH of Wood Apple nectar after 90 days of storage was decreased to 3.20 from initial pH of 3.35. The change in the pH was significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.036). Aruna *et al.* (1997) showed the pH value of

3.71 to 3.45 after 9 months of storage. The results were found in conformity with the results observed in the present study.

The TSS of the Wood Apple nectar on zero day was 12.40°Brix. A gradual increase in the TSS of Wood Apple nectar was observed during the storage. The change in the TSS of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22a). The TSS of Wood Apple nectar upto 15 days of storage was 12.42°Brix from initial TSS content of 12.40°Brix. The change in the TSS content of nectar was non significant. The TSS of Wood Apple nectar after 30 days was increased to 12.64°Brix. There was significant difference ($P \leq 0.05$) in the TSS of the product during the storage period. The value of TSS of Wood Apple nectar after 45 days storage was increased to 12.76°Brix and showed a significant difference ($P \leq 0.05$). The value of TSS of Wood Apple nectar after 60 days storage was 12.82°Brix. The results showed regular increase in TSS. The increment in the TSS may be due to increase in soluble solid content. The difference in the TSS content was significantly different ($P \leq 0.05$). The value of TSS of Wood Apple nectar after 75 days of storage was 13.06°Brix and showed a significant difference ($P \leq 0.05$). The TSS content of Wood Apple nectar after 90 days of storage was increased to 13.28°Brix from initial TSS of 12.42 °Brix. The change in the TSS was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.025). Aruna *et al.* (1997) also observed that the TSS of Papaya nectar was significantly decreased as the period of storage increased (17.50 to 16.2). These results are in agreement with the TSS of nectar prepared from Mango varieties (Gunjal and Waghmare, 1987; Gunjal *et al.*, 1997; Chakraborthy *et al.*, 1991). The results were found in conformity with the results observed in the present study.

The ash content of the Wood Apple nectar on zero day was 0.27 per cent. No appreciable change in the ash content was observed during the storage. The change in the ash content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The ash content of Wood Apple nectar upto 60 days of storage was 0.27 per cent that was similar to the ash content at zero day (0.27 per cent). The percentage of ash content of Wood Apple nectar after 75 and 90 days of storage was 0.28. The change in the ash content was non significant.

The calcium content of the Wood Apple nectar on zero day was 105.04 mg/100g. The change in the calcium content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The calcium content of Wood Apple nectar after 15 days of storage was 105.04 mg/100g that was similar to the calcium content at zero day (105.04 mg/100g). There was non significant change in the calcium content. The value of calcium content of Wood Apple nectar after 30 and 45 days of storage was 105.05 mg/100g and showed a non significant change during storage. The percentage of calcium content of Wood Apple nectar upto 90 days of storage was 105.06 mg/100g that was similar to the calcium content at 60 days storage (105.06 mg/100g). The change in the calcium content was non significant from zero day (105.04 mg/100g) to 90 days (105.06 mg/100g).

The phosphorus content of the Wood Apple nectar on zero day was 18.94 mg/100g. The change in the phosphorus content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The phosphorus content of Wood Apple nectar upto 30 days of storage was 18.94 mg/100g that was similar to the initial value of phosphorus content 18.94 mg/100g. The change in the phosphorus content of nectar was non significantly different. The value of phosphorus content of Wood Apple nectar on 60 days was 18.95 mg/100g and showed non significant difference. The results showed slight increment in phosphorus content. The phosphorus content of Wood Apple nectar upto 90 days of storage was 18.96 mg/100g from initial phosphorus content of 18.94 mg/100g. The change in phosphorus content of Wood Apple nectar was non significant.

The total sugar of the Wood Apple nectar on zero day was 11.22 per cent. During the storage period the ascorbic acid content showed a declining trend in Wood Apple nectar. The change in the ascorbic acid content of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The total sugar of Wood Apple nectar after 15 days of storage was decreased to 11.16 per cent from initial total sugar content of 11.22 per cent. The change in the total sugar content of nectar was significantly different ($P \leq 0.05$). The percentage of total sugar of Wood Apple nectar after 30 days was 10.94. There was significant difference ($P \leq 0.05$) in the total sugar of the product during the storage period. The percentage of total sugar of Wood Apple nectar after 45 days storage was decreased to 10.64 and showed a significant difference ($P \leq 0.05$). The percentage of total sugar of Wood Apple nectar

after 60 days storage was 10.28. The results showed regular decline in total sugar. The decline in the total sugar may be due to the change in the moisture content or degradation of sugar during storage. The difference in the total sugar was significantly different (P≤ 0.05). The percentage of total sugar of Wood Apple nectar after 75 days of storage was 10.02 and showed a significant difference (P≤ 0.05). The total sugar of Wood Apple nectar after 90 days of storage was decreased to 9.86 per cent from initial total sugar content of 11.22 per cent. The change in the total sugar was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006). Aruna *et al.* (1997) reported that a significance decrease in total sugar (16.41 to 14.78) in Papaya nectar was observed as the period of storage (9 months) increased. A similar trend was observed in literature (Roy *et al.*, 1972; Gunjal and Waghmare, 1987; Gunjal *et al.*, 1987 and Chakraborthy *et al.*, 1991). The decrease in total sugar content during storage was observed in number of beverages, (Roy, 1992; Dhaliwal and Heera, 2001 and Sharma *et al.*, 2001). The results were found in conformity with the results observed in the present study.

The reducing sugar of the Wood Apple nectar on zero day was 4.78 per cent. A gradual increase in the reducing sugar of Wood Apple nectar was observed on the storage. The change in the reducing sugar of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The reducing sugar of Wood Apple nectar after 15 days of storage was 4.82 per cent from initial reducing sugar of 4.78 per cent. The change in the reducing sugar of nectar was significantly different (P≤ 0.05). The value of reducing sugar of Wood Apple nectar after 30 days was increased to 4.93 per cent. There was significant difference (P≤ 0.05) in the reducing sugar of the product during the storage period. The value of reducing sugar of Wood Apple nectar after 45 days storage was increased to 5.08 per cent and showed a significant difference (P≤ 0.05). The value of reducing sugar of Wood Apple nectar after 60 days storage was 5.18 per cent. The results showed regular increment in reducing sugar. The increase in reducing sugars during storage has been attributed to inversion of disaccharide under acidic conditions. The difference in the reducing sugar was significantly different (P≤ 0.05). The value of reducing sugar of Wood Apple nectar after 75 days of storage was 5.25 per cent and showed a significant difference (P≤ 0.05). The reducing sugar of Wood Apple nectar after 90 days of storage was increased to 5.32 per cent from initial reducing sugar content of 4.78 per cent. The change in the reducing sugar was highly significant (P= 0.00) at 5

per cent level of significance (CD = 0.006). Khurdiya and Sagar (1991) reported that the reducing sugar was increased from 6.35 to 14.82 per cent during 12 months of storage. The results were found in conformity with the results observed in the present study.

The non reducing sugar of the Wood Apple nectar on zero day was 6.44 per cent. During the storage period the non reducing sugar showed a declining trend in Wood Apple nectar. The change in the non reducing sugar of nectar was assessed during the storage period of 90 days with an interval of 15 days (Table 4.22b). The non reducing sugar of Wood Apple nectar after 15 days of storage was decreased to 6.34 per cent from initial non reducing sugar content of 6.44 per cent. The change in the non reducing sugar of nectar was significantly different ($P \leq 0.05$). The percentage of non reducing sugar of Wood Apple nectar after 30 days was 6.01. There was significant difference ($P \leq 0.05$) in the non reducing sugar of the product during the storage period. The percentage of non reducing sugar of Wood Apple nectar after 45 days storage was decreased to 5.56 and showed a significant difference ($P \leq 0.05$). The percentage of non reducing sugar of Wood Apple nectar after 60 days storage was 5.10. The results showed regular decline in non reducing sugar. The decline in the non reducing sugar may be due to the conversion of non-reducing sugars to reducing sugars during storage. The difference in the non reducing sugar was significantly different ($P \leq 0.05$). The percentage of non reducing sugar of Wood Apple nectar after 75 days of storage was 4.77 and showed a significant difference ($P \leq 0.05$). The non reducing sugar of Wood Apple nectar after 90 days of storage was decreased to 4.54 per cent from initial non reducing sugar content of 6.44 per cent. The change in the non reducing sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.010). A significance decrease in non reducing sugar from 10.44 to 7.77 per cent in Papaya nectar was observed during 9 months storage (Aruna *et al.*, 1997). The results were found in conformity with the results observed in the present study.

4.3.2.2 *Organoleptic evaluation*

The acceptability of Wood Apple nectar was evaluated by a ten member panel. The value of the scores of sensory evaluation is a tool for the evaluation of the quality of the product developed. This tool depends on the objectivity, precision and reproductively of the judgment of the panelists (Pal *et al.*, 1995). The sensory feed back of Wood Apple nectar was taken on a 9 point hedonic scale (Appendix II), from

panel members, on the different quality parameters (colour, flavour, taste and overall acceptability). The data of the same was analysed to test the significance between the products (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

4.3.2.2.1 *Changes in the organoleptic qualities during storage*

The final product was stored for the determination of storage quality. The effect of storage on the organoleptic qualities of fruit nectar was assessed during a storage period of 90 days with an interval of 15 days (Table 4.23).

The score for colour of Wood Apple nectar on zero day was 8.10. During the storage period the colour score showed a declining trend in Wood Apple nectar. The changes in the colour score of nectar samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.23). The initial sensory score for colour of Wood Apple nectar was 8.10, which had decreased to 7.85 after 15 days. The change in the colour score of nectar was significantly different ($P \leq 0.05$). The sensory score for colour of Wood Apple nectar after 30 days was decreased to 7.80. There was significant difference ($P \leq 0.05$) in the colour score of the nectar during the storage period. The sensory score for colour of Wood Apple nectar after 45 days storage was decreased to 7.75 and showed a significant difference ($P \leq 0.05$). The sensory score for colour of Wood Apple nectar after 60 days storage was decreased to 7.65 and showed regular decline in colour score. The difference in the colour score was significantly different ($P \leq 0.05$). The sensory score for colour of Wood Apple nectar after 75 days of storage was 7.35 and showed a significant difference ($P \leq 0.05$). The colour score of Wood Apple nectar after 90 days of storage was decreased to 7.0 from initial colour score 8.10. The results showed the change in the colour score was significant at 5 per cent level of significance (CD = 0.224). Aruna *et al.* (1997) also noticed the insignificant changes in colour and apPearance (from 4.75 to 4.50) of Papaya nectar during 9 months storage. The results were found in conformity with the results observed in the present study.

Table 4.22a: Changes in chemical constituents of Wood Apple nectar during storage

Storage Period (Month)	Moisture %	Protein %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	83.78	0.86	37.50	0.53	3.35	12.40
15 Days	83.78	0.80	36.70	0.53	3.35	12.42
30 Days	83.76	0.78	34.78	0.53	3.33	12.64
45 Days	83.7	0.74	31.90	0.54	3.30	12.76
60 Days	83.62	0.72	30.28	0.54	3.28	12.82
75 Days	83.54	0.69	27.86	0.55	3.22	13.06
90 Days	83.45	0.65	26.53	0.55	3.20	13.28
CD (5%)	0.006	0.006	0.043	0.006	0.036	0.025
P Value	0.00	0.00	0.00	0.02	0.01	0.00

Table 4.22b: Changes in chemical constituents of Wood Apple nectar during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	0.27	105.04	18.94	11.22	4.78	6.44
15 Days	0.27	105.04	18.94	11.16	4.82	6.34
30 Days	0.27	105.05	18.94	10.94	4.93	6.01
45 Days	0.27	105.05	18.95	10.64	5.08	5.56
60 Days	0.27	105.06	18.95	10.28	5.18	5.10
75 Days	0.28	105.06	18.96	10.02	5.25	4.77
90 Days	0.28	105.06	18.96	9.86	5.32	4.54
CD (5%)	NS	NS	NS	0.006	0.006	0.01
P Value	0.64	0.08	0.08	0.00	0.00	0.00

The score for flavour of Wood Apple nectar on zero day was 8.25. During the storage period the flavour score showed a declining trend in Wood Apple nectar. The changes in the flavour score of nectar samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.23). The initial sensory score for flavour of Wood Apple nectar was 8.25, which had decreased to 7.75 after 15 days. The change in the flavour score of nectar was significantly different ($P \leq 0.05$). The sensory score for flavour of Wood Apple nectar after 30 days was decreased to 7.65. There was significant difference ($P \leq 0.05$) in the flavour score of the nectar during the storage period. The sensory score for flavour of Wood Apple nectar after 45 days storage was decreased to 7.50 and showed a significant difference ($P \leq 0.05$). The sensory score for flavour of Wood Apple nectar after 60 days storage was decreased to 7.35 and showed regular decline in flavour score. The decline in the flavour score may be due to the change in the sugar and fat during storage. The difference in the flavour score was significantly different ($P \leq 0.05$). The sensory score for flavour of Wood Apple nectar after 75 days of storage was 7.15 and showed a significant difference ($P \leq 0.05$). The flavour score of Wood Apple nectar after 90 days of storage was decreased to 6.95 from initial flavour score of 8.25. The results showed the change in the flavour score was significant at 5 per cent level of significance (CD = 0.268). Flavour of Papaya nectar after 9 months showed the decline trend (4.25 to 3.63) but the changes were non-significant (Aruna *et al.*, 1997). The results were found in conformity with the results observed in the per cent study.

The score for taste of Wood Apple nectar on zero day was 7.95. During the storage period the taste score showed a declining trend in Wood Apple nectar. The changes in the taste score of nectar samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.23). The initial sensory score for taste of Wood Apple nectar was 7.95, which had decreased to 7.65 after 15 days. The change in the taste score of nectar was significantly different ($P \leq 0.05$). The sensory score for taste of Wood Apple nectar after 30 days was decreased to 7.55. There was significant difference ($P \leq 0.05$) in the taste score of the nectar during the storage period. The sensory score for taste of Wood Apple nectar after 45 days storage was decreased to 7.50 and showed a significant difference ($P \leq 0.05$). The sensory score for taste of Wood Apple nectar after

60 days storage was decreased to 7.35 and showed regular decline in taste score. The decline in the taste score may be due to the changes in the product during storage. The difference in the taste score was significantly different ($P \leq 0.05$). The sensory score for taste of Wood Apple nectar after 75 days of storage was 7.00 and showed a significant difference ($P \leq 0.05$). The taste score of Wood Apple nectar after 90 days of storage was decreased to 6.9 from initial taste score of 7.95. The results showed the change in the taste score was significant at 5 per cent level of significance (CD = 0.211). Taste of Papaya nectar after 9 months showed the decline trend (4.50 to 3.88) but the changes were non-significant (Aruna *et al.*, 1997). The results were found in conformity with the results observed in the present study.

The score for overall acceptability of Wood Apple nectar on zero day was 8.10. During the storage period the overall acceptability score showed a declining trend in Wood Apple nectar. The changes in the overall acceptability score of nectar samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.23). The initial sensory score for overall acceptability of Wood Apple nectar was 8.10, which had decreased to 7.75 after 15 days. The change in the overall acceptability score of nectar was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple nectar after 30 days was decreased to 7.66. There was significant difference ($P \leq 0.05$) in the overall acceptability score of the nectar during the storage period. The sensory score for overall acceptability of Wood Apple nectar after 45 days storage was decreased to 7.58 and showed a significant difference ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple nectar after 60 days storage was decreased to 7.45 and showed regular decline in overall acceptability score. The decline in the overall acceptability score may be due to the change in colour, flavour, texture etc. The difference in the overall acceptability score was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple nectar after 75 days of storage was 7.16 and showed a significant difference ($P \leq 0.05$). The overall acceptability score of Wood Apple nectar after 90 days of storage was decreased to 6.95 from initial overall acceptability score of 8.1. The results showed that the change in the overall acceptability score was significant at 5 per cent level of significance (CD = 0.153). Similarly, in

Papaya nectar overall acceptability declined during six and nine month storage was 4.50 to 3.94, respectively (Aruna *et al.*, 1997). The results were found in conformity with the results observed in the present study.

4.3.2.3 *Microbiological analysis*

Microbial food safety is an essential component of food quality. Quality is a combination of characteristics that have significance in determining the degree of acceptability of the product to a consumer. The microbial quality of the Wood Apple nectar was observed periodically. Microbiological changes were evaluated at the interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature (2-5°C).

The total plate count was nil at initial stage of storage. The effect of storage on the quality of Wood Apple nectar was assessed during a storage period of 90 days with an interval of 15 days (Table 4.24). Total plate counts were not observed upto 45 days of storage. Minimum total plate count in Wood Apple nectar was 7.5×10^2 cfu/ml after 90 days of storage. Yeast and mould counts in Wood Apple nectar were nil at initial days of storage. Yeast and mould counts were not recorded upto 45 days storage while after 90 days the yeast and mould count were 1.5×10^2 cfu/ml. Coliform count was found to be nil throughout the storage period. This indicated that the Wood Apple nectar remained safe microbiologically during storage and the nectar was found acceptable after 90 days at refrigeration temperature. Aruna *et al.* 1997 reported that yeast and mould counts were not observed throughout the study but bacterial counts were observed (4.0×10^1) from 6 months storage onwards and doubled (3.5×10^2) after 9 months storage. The data was found in conformity with the results observed in the present study.

Table 4.23: Changes in sensory attributes in Wood Apple nectar during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	8.10	8.25	7.95	8.10
15 Days	7.85	7.75	7.65	7.75
30 Days	7.80	7.65	7.55	7.66
45 Days	7.75	7.50	7.50	7.58
60 Days	7.65	7.35	7.35	7.45
75 Days	7.35	7.15	7.00	7.16
90 Days	7.00	6.95	6.9	6.95
CD (5%)	0.224	0.268	0.211	0.153
P Value	0.03	0.03	0.01	0.00

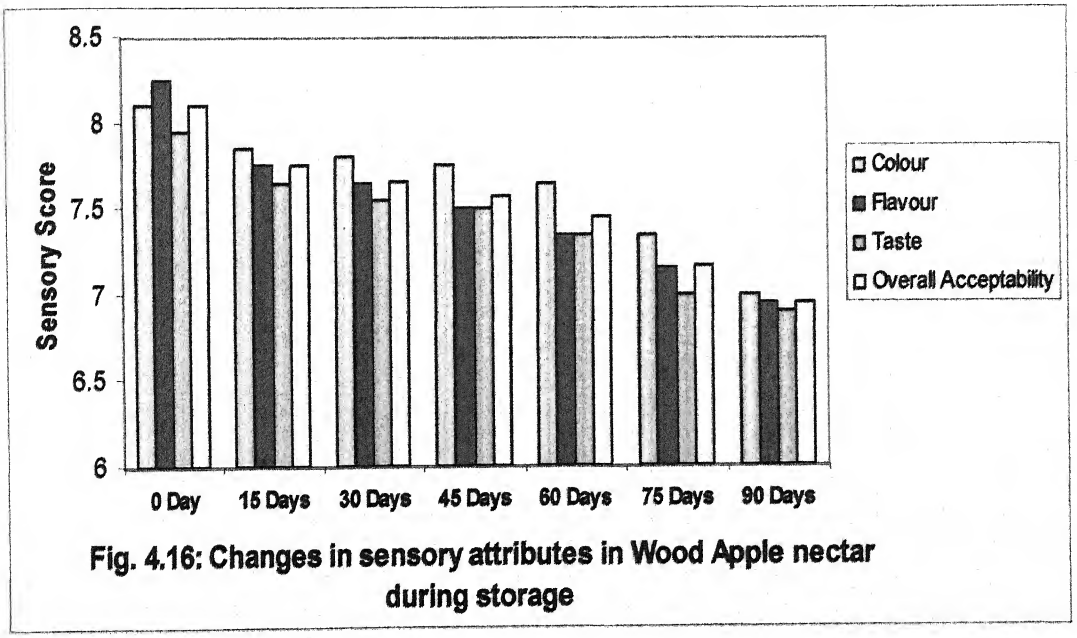


Fig. 4.16: Changes in sensory attributes in Wood Apple nectar during storage

Table 4.24: Microbial counts in Wood Apple nectar during storage

Treatments	Total Plate Counts	Yeast & Mould Counts
0 Days	0	0
15 Days	0	0
30 Days	0	0
45 Days	0	0
60 Days	5.0×10^1	1.0×10^1
75 Days	6.5×10^2	1.0×10^2
90 Days	7.5×10^2	1.5×10^2
CD (5%)	0.435	0.435
P Value	0.00	0.04

4.4 PREPARATION OF THE WOOD APPLE BLENDED BEVERAGE (COCKTAIL)

4.4.1 Standardization of the Parameters

Wood Apple pulp was blended with two different types of pulp i.e. Mango pulp and Ginger pulp in different ratios for the preparation of blended beverage. Ginger pulp was mixed in four different percentages 3, 5, 7 and 10, among them 5 per cent of Ginger pulp was acceptable. Wood Apple pulp was mixed with Mango pulp and standardized with Ginger pulp (5 per cent) in the ratios of 90:5:5, 80:15:5, 70:25:5 and 60:35:5 (Wood Apple pulp: Mango pulp: Ginger pulp), respectively. The blended beverage (cocktail) was prepared and evaluated by a sensory panel of 10 members by using 9 point hedonic scale. Two types of flavours (cola and orange) were added to the blended beverage. The highest sensory score of 8.24 was found for orange flavour in blended beverage (Table 4.29). The sensory score for orange flavour blended beverage was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.410).

4.4.1.1 *Standardization of Wood Apple pulp percentage*

Wood Apple pulp was used for the preparation of blended beverage. The blended beverage was prepared by standard method. The percentage of Wood Apple pulp in the blended beverage was standardized by incorporation of 60, 70, 80 and 90 per cent pulp (Table 4.25). The sensory score for 60, 70, 80 and 90 per cent Wood Apple pulp in blended beverage was 6.93, 6.75, 8.00 and 6.51, respectively. The blended beverage made of 80 per cent pulp was found highest score (8.0) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.001). The best score for 80 per cent Wood Apple pulp was due to the more acceptable flavour and taste. The colour of the 90 per cent Wood Apple pulp was dark and the blended beverage was more acidic in nature. The taste of 60 and 70 per cent Wood Apple pulp in blended beverage was very low due to low concentration of Wood Apple pulp.

4.4.1.2 *Standardization of the Ginger pulp percentage*

Ginger pulp was used for the preparation of blended beverage. The blended beverage was prepared by standard method. The percentage of Ginger pulp in the blended

beverage was standardized by incorporation of 3, 5, 7 and 10 per cent pulp (Table 4.26). The sensory score for 3, 5, 7 and 10 per cent Ginger pulp in blended beverage was 7.71, 7.83, 7.32 and 6.56, respectively. The blended beverage made of 5 per cent pulp received maximum score of 7.78 and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.22). The best score for 5 per cent Ginger pulp was due to the more acceptable flavour and taste. The flavour of the 7 and 10 per cent Ginger pulp was not acceptable due to the strong flavour of Ginger. The taste of 3 per cent Ginger pulp was very low due to low concentration of Ginger pulp.

The blended beverage made from 60, 70, 80 and 90 per cent Wood Apple pulp and 3, 5, 7 and 10 per cent Ginger pulp secured sensory score of 6.93, 6.75, 8.00 and 6.51 and 7.71, 7.83, 7.32 and 6.56, respectively. The ratio of pulps for blended beverage was 80:15:5 (Wood Apple pulp: Mango pulp: Ginger pulp), used for further study.

4.4.1.3 *Standardization of sugar percentage*

Sugar content was standardized by incorporation of 10, 15 and 20 per cent sugar (Table 4.27). The sensory score for 10, 15 and 20 per cent sugar in blended beverage was 6.53, 7.61 and 6.86, respectively. The sensory score for 15 per cent sugar was found highest (7.61) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.312). The best score for 15 per cent sugar was due to low sweetness of 10 per cent sugar while very high sweetness for 20 per cent sugar content. The sugar content of 15 per cent was selected for further study.

4.4.1.4 *Standardization of citric acid percentage*

The percentage of citric acid in the blended beverage was standardized by incorporation of 0.15, 0.25, 0.50 and 1.0 per cent citric acid (Table 4.28). The sensory score for 0.15, 0.25, 0.50 and 1.0 per cent citric acid in blended beverage was 7.01, 7.05, 7.96 and 6.46, respectively.

Table 4.25: Standardization of the percentage of Wood Apple pulp in blended beverage

Treatment	Colour	Flavour	Taste	Overall Acceptability
WAP (60%)	6.99	6.85	6.95	6.93
WAP (70%)	6.87	6.78	6.60	6.75
WAP (80%)	8.04	7.83	8.15	8.00
WAP (90%)	6.75	6.60	6.20	6.51
CD (5%)	0.299	0.328	0.345	0.288
P value	0.00	0.00	0.00	0.00

Table 4.26: Standardization of the percentage of Ginger pulp in blended beverage

Treatment	Colour	Flavour	Taste	Overall Acceptability
GP 3%	8.20	7.60	7.35	7.71
GP 5%	7.60	8.00	7.90	7.83
GP 7%	7.50	7.10	7.36	7.32
GP 10%	7.05	6.45	6.20	6.56
CD (5%)	NS	0.286	0.323	0.220
P value	0.09	0.00	0.00	0.00

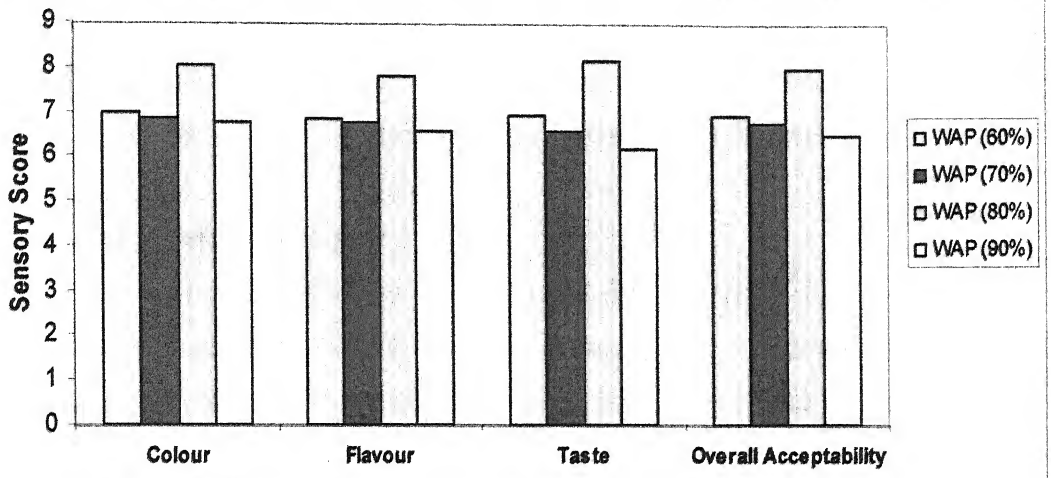


Fig. 4.17: Standardization of the percentage of Wood Apple pulp in blended beverage

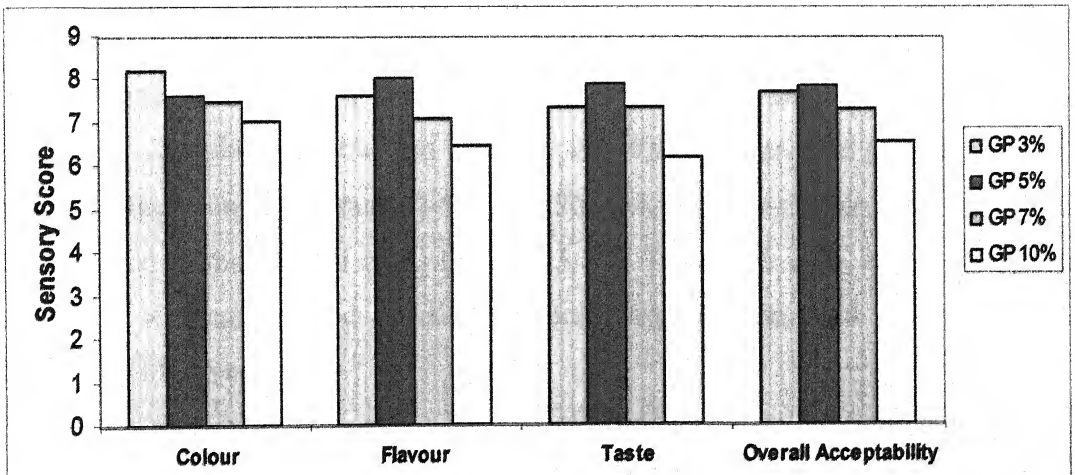


Fig. 4.18: Standardization of the percentage of Ginger pulp in blended beverage

The blended beverage made from 0.50 per cent citric acid highest sensory score (8.06) and this was significantly different (P≤ 0.05) in comparison to other combinations (CD = 0.304).The best score for 0.50 per cent citric acid was due to low acidic taste of 0.15 and 0.25 per cent citric acid while very high acidic taste for 1.0 per cent citric acid. The taste of 0.50 per cent was more acceptable in comparison to 0.15 and 0.25 per cent due to more palatablility. The citric acid of 0.50 per cent was selected for further study.

4.4.1.5 Standardization of flavour

Flavour was standardized by incorporation of cola and orange flavour (Table 4.29). The sensory score for control, cola and orange flavour in blended beverage was 6.80, 8.25 and 6.16, respectively. The sensory score for orange flavour was found highest (8.24) and this was significantly different (P≤ 0.05) in comparison to other combinations (CD = 0.410).

The flavoured blended beverage (orange flavour) made from 80 per cent Wood Apple pulp, 15 per cent Mango pulp and 5 per cent Ginger pulp secured highest score of 8.24 than cola flavoured blended beverage (6.16) and was used for further study (Table 4.9).

4.4.2 Storage Study

The selected flavoured blended beverage (orange flavour) was stored for the storage study. The flavoured blended beverage was filled in sterilized glass bottles and stored at refrigeration temperature (2-5°C) for 90 days. Physico-chemical characteristics were evaluated at the interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature and physico-chemical, organoleptic, and microbiological changes were observed.

Table 4.27: Standardization of the percentage of sugar in blended beverage

Treatment	Colour	Flavour	Taste	Overall Acceptability
Sugar (10%)	6.4	6.65	6.54	6.53
Sugar (15%)	7.85	7.5	7.5	7.61
Sugar (20%)	7.2	6.85	6.54	6.86
CD (5%)	0.424	0.414	0.286	0.312
P value	0.00	0.08	0.00	0.00

Table 4.28: Standardization of the percentage of citric acid in blended beverage

Treatment	Colour	Flavour	Taste	Overall Acceptability
CA (0.15%)	7.20	6.45	7.40	7.01
CA (0.25%)	7.10	6.95	7.10	7.05
CA (0.50%)	7.80	7.90	8.00	7.96
CA (1.0%)	6.80	5.90	6.70	6.46
CD (5%)	0.348	0.373	0.378	0.304
P value	0.76	0.00	0.00	0.00

Table 4.29: Standardization of the flavour in Wood Apple blended beverage

Treatment	Colour	Flavour	Taste	Overall Acceptability
Control	6.65	6.90	6.85	6.80
Orange flavour	8.40	8.00	8.35	8.25
Cola flavour	5.80	6.30	6.40	6.16
CD (5%)	0.694	0.445	0.450	0.410
P value	0.00	0.00	0.00	0.00

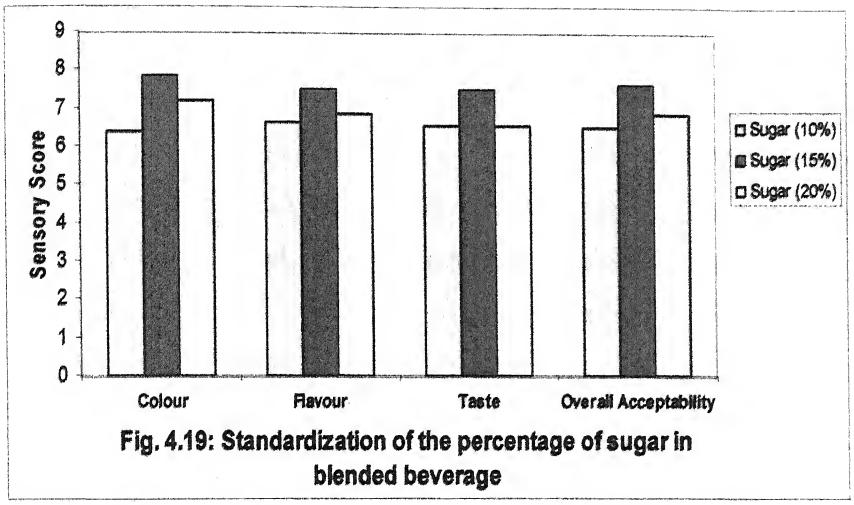


Fig. 4.19: Standardization of the percentage of sugar in blended beverage

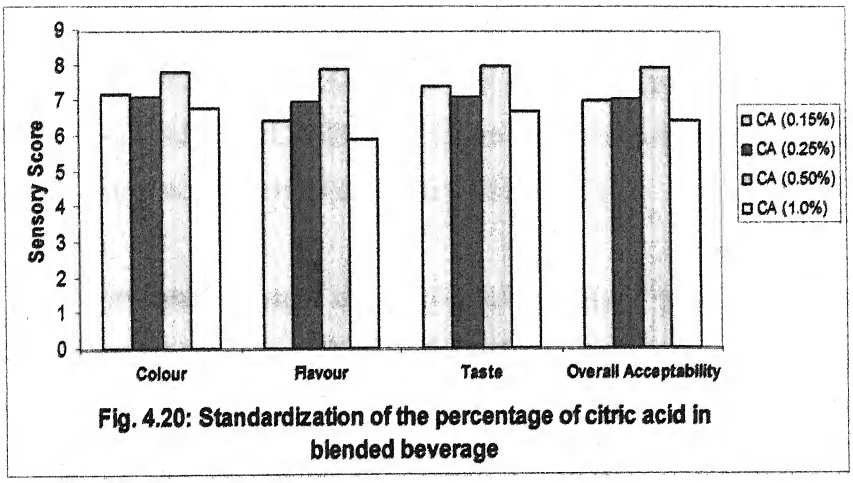


Fig. 4.20: Standardization of the percentage of citric acid in blended beverage

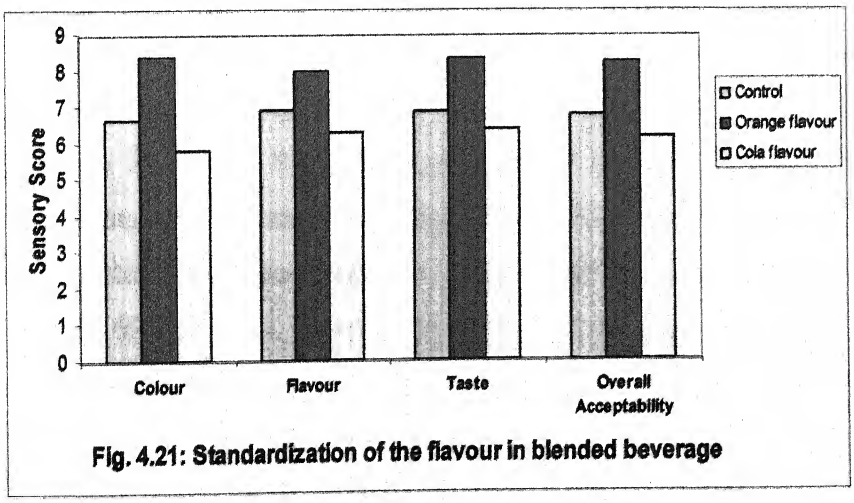


Fig. 4.21: Standardization of the flavour in blended beverage

4.4.2.1 *Physico-chemical characteristics*

The chemical constituents present in Wood Apple fruit influence the nutritional and storage qualities of the product. The blended beverage (control) and flavoured blended beverage (orange flavour) were analysed for proximate composition as per the approved methods. Moisture content was analysed by oven drying method, ascorbic acid content by titration method using 2, 6, dichlorophenol indophenol dye, total ash, total acidity (as anhydrous citric acid), carbohydrate, sugars (Lane and Eynon, 1923), protein by micro-kjeldahl method, calcium and phosphorus were determined by the procedures described by Ranganna (2003). The pH of the beverage was determined by pH meter while total soluble solids (TSS) were determined by hand Refractometer (Ranganna, 1986). All constituents were analysed at 0, 15, 30, 45, 60, 75 and 90 days of storage at refrigeration temperature (2-5°C).

4.4.2.1.1 *Physico-chemical changes*

The beverages were stored for 90 days and the changes in moisture, protein, ascorbic acid, acidity, pH, TSS, ash, sugars and minerals were observed. The results of the observations are presented in Table 4.30 and 4.31.

The moisture content of the blended beverage (control) and flavoured blended beverage on zero day was 82.76 and 82.60 per cent, respectively. During the storage period the moisture content showed a declining trend in blended beverage (control) and flavoured blended beverage. The changes in the moisture content of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The initial moisture content of blended beverage (control) and flavoured blended beverage was 82.76 and 82.60 per cent, respectively, which had decreased to 82.71 and 82.56 per cent after 15 days of storage. The change in the moisture content of beverages was significantly different ($P \leq 0.05$). The percentage of moisture content of blended beverage (control) and flavoured blended beverage after 30 days was 82.69 and 82.52, respectively. There was significant difference ($P \leq 0.05$) in the moisture content of the beverage during the storage period. The percentage of moisture content of blended beverage (control) and flavoured blended beverage after 45 days of

storage was 82.65 and 82.48, respectively and showed a significant difference (P≤ 0.05). The percentage of moisture content of blended beverage (control) and flavoured blended beverage after 60 days storage was 82.61 and 42.44, respectively. The results showed regular decline in moisture content. The decline in the moisture content may be due to the evaporation of moisture from the beverage during storage. The difference in the moisture content was significantly different (P≤ 0.05). The percentage of moisture content of blended beverage (control) and flavoured blended beverage after 75 days of storage was 82.50 and 82.33, respectively and showed a significant difference (P≤ 0.05). The moisture content of blended beverage (control) and flavoured blended beverage after 90 days of storage was decreased to 82.42 and 82.25 per cent from initial moisture content of 82.76 and 82.60 per cent. The change in the moisture content was highly significant (P= 0.00) at 5 percent level of significance (CD = 0.006 and 0.025).

The protein content of the blended beverage (control) and flavoured blended beverage on zero day was 0.65 and 0.68 per cent, respectively. During the storage period the protein content showed a declining trend in blended beverage (control) and flavoured blended beverage. The changes in the protein content of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The initial protein content of blended beverage (control) and flavoured blended beverage was 0.65 and 0.68 per cent, respectively, which had decreased to 0.60 and 0.66 per cent after 15 days of storage. The change in the protein content of beverage samples was significantly different (P≤ 0.05). The percentage of protein content of blended beverage (control) and flavoured blended beverage after 30 days was decreased to 0.59 and 0.64, respectively. There was significant difference (P≤ 0.05) in the protein content of the product during the storage period. The percentage of protein content of blended beverage (control) and flavoured blended beverage after 45 days storage was decreased to 0.51 and 0.58, respectively and showed a significant difference (P≤ 0.05). The percentage of protein content of blended beverage (control) and flavoured blended beverage after 60 days storage was 0.48 and 0.54, respectively. The protein content showed regular decline in protein content. The difference in the protein content was significantly different (P≤ 0.05). The percentage of protein content of blended beverage (control) and flavoured

blended beverage after 75 days of storage was 0.42 and 0.50, respectively and showed a significant difference (P≤ 0.05). The protein content of blended beverage (control) and flavoured blended beverage after 90 days of storage was decreased to 0.40 and 0.48 per cent from initial protein content of 0.65 and 0.68 per cent, respectively. The change in the protein content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.006).

The ascorbic acid content of the blended beverage (control) and flavoured blended beverage on zero day was 25.75 and 28.75 mg/100g, respectively. During the storage period the ascorbic acid content showed a declining trend in blended beverage (control) and flavoured blended beverage. The changes in the ascorbic acid content of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The initial ascorbic acid content of blended beverage (control) and flavoured blended beverage was 25.75 and 28.75 mg/100g, respectively, which had decreased to 23.51 and 26.64 mg/100g after 15 days of storage. The change in the ascorbic acid content of beverages was significantly different (P≤ 0.05). The value of ascorbic acid content of blended beverage (control) and flavoured blended beverage after 30 days was decreased to 21.28 and 24.86 mg/100g, respectively. There was significant difference (P≤ 0.05) in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of blended beverage (control) and flavoured blended beverage after 45 days storage was decreased to 20.95 and 23.21 mg/100g, respectively and showed a significant difference (P≤ 0.05). The value of ascorbic acid content of blended beverage (control) and flavoured blended beverage after 60 days storage was 18.51 and 20.84 mg/100g, respectively. The results showed regular decline in ascorbic acid content. The decline in the ascorbic acid content may be due to the degradation of ascorbic acid during storage. The difference in the ascorbic acid content was significantly different (P≤ 0.05). The value of ascorbic acid content of blended beverage (control) and flavoured blended beverage after 75 days of storage was 17.35 and 19.72 mg/100g, respectively and showed a significant difference (P≤ 0.05). The ascorbic acid content of blended beverage (control) and flavoured blended beverage after 90 days of storage was decreased to 16.70 and 18.36 mg/100g from initial ascorbic acid content of 25.75 and

28.75 mg/100g, respectively. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 mg/100g level of significance (CD = 0.006 and 0.006).

The acidity of the blended beverage (control) and flavoured blended beverage on zero day was 0.51 and 0.48 per cent, respectively. A gradual increase in the acidity of blended beverage (control) and flavoured blended beverage was observed during storage. The changes in the acidity content of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The initial acidity of blended beverage (control) after 15 days was 0.51 per cent that was similar to the acidity content of zero days (0.51 per cent) and showed non significant change while the acidity content of flavoured blended beverage after 15 days was increased to 0.50 and showed significant difference (P≤ 0.05). The percentage of acidity of blended beverage (control) and flavoured blended beverage after 30 days was increased to 0.52 and 0.51, respectively. There was significant difference (P≤ 0.05) in the acidity of the product during the storage period. The acidity of blended beverage (control) after 45 days was increased to 0.53 per cent and showed significant (P≤ 0.05) change while the acidity content of flavoured blended beverage upto 45 days was 0.51 per cent that was similar to the acidity content after 30 days of storage (0.51 per cent) and showed non significant change. The acidity of blended beverage (control) after 60 days was 0.53 per cent that was similar to the acidity content of zero days (0.53 per cent) and showed non significant change while the acidity content of flavoured blended beverage after 60 days was increased to 0.52 and showed significant difference (P≤ 0.05). The percentage of acidity was increased due to the conversion of sugars to acids during storage. The difference in the acidity was significantly different (P≤ 0.05). The acidity of blended beverage (control) after 75 days was increased to 0.54 per cent and showed significant change (P≤ 0.05) while the acidity content of flavoured blended beverage upto 75 days was 0.51 per cent that was similar to the acidity content after the 60 days of storage (0.51 per cent) and showed non significant change. The acidity of blended beverage (control) and flavoured blended beverage after 90 days of storage increased to 0.55 and 0.53 per cent from initial acidity content of 0.51 and 0.48 per cent, respectively. The change in the acidity content was significant at 5 per cent level of significance (CD = 0.006 and 0.006). Sandhu and

Sindhu (1992) mentioned 0.56, 0.69 and 0.46 per cent acidity in the blends of Grape: Mango (75:25), Kinnow: Mango: Pineapple (50:25:25) and Kinnow: Mango: Pear: Grape (25: 25: 25:25), respectively. The acidity in RTS drink prepared from the above blends was 0.36, 0.37 and 0.30 per cent, respectively. Shukla *et al.* (2005) observed that the acidity content of Whey-Apple juice beverage was increased from 0.53 to 0.72 per cent at refrigeration temperature after 6 months of storage. The data were found in conformity with the results observed in the present study.

The pH of the blended beverage (control) and flavored blended beverage on zero day was 3.60 and 3.72, respectively. During the storage period the pH showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the pH of beverages were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The initial pH of blended beverage (control) and flavored blended beverage was 3.60 and 3.72, respectively, which had decreased to 3.59 and 3.70 after 15 days of storage and showed significant difference ($P \leq 0.05$). The value of pH of blended beverage (control) and flavored blended beverage after 30 days was decreased to 3.50 and 3.69, respectively. There was significant difference ($P \leq 0.05$) in the pH of the product during the storage period. The value of pH of blended beverage (control) and flavored blended beverage after 45 days storage was 3.48 and 3.62, respectively and showed a significant difference ($P \leq 0.05$). The value of pH of blended beverage (control) and flavored blended beverage after 60 days storage was 3.47 and 3.58, respectively. The results showed regular decline in pH. Increase in acidity could be the reason for decrease in the pH of the beverages during storage. The difference in the pH was significantly different ($P \leq 0.05$). The value of pH of blended beverage (control) and flavored blended beverage after 75 days of storage was 3.41 and 3.52, respectively and showed a significant difference ($P \leq 0.05$). The pH of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 3.38 and 3.44 from initial pH of 3.60 and 3.72, respectively. The change in the pH was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.036 and 0.006).

The TSS of the blended beverage (control) and flavored blended beverage on zero day was 12.2 and 12.0°Brix, respectively. A remarkable increase in the TSS of blended beverage (control) and flavored blended beverage was observed during the storage. The changes in the TSS of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30a and 4.31a). The TSS content of blended beverage (control) and flavored blended beverage upto 15 days was 12.2 and 12.0°Brix, respectively, that was similar to the TSS content of the zero days (12.2 and 12°Brix). The change in the TSS of beverage samples was non significant. The TSS of the blended beverage (control) and flavored blended beverage upto 45 days was 12.3 and 12.4°Brix and showed non significant changes. The TSS of blended beverage (control) from 60 days to 90 days of storage was 12.4°Brix and showed non significant difference while flavored blended beverage after 60 and 75 days of storage was 12.6 and 12.8°Brix, respectively. The changes in the TSS was non significant. The TSS content of blended beverage (control) and flavored blended beverage upto 90 days of storage was 12.4 and 12.8°Brix from initial TSS content of 12.2 and 12.0°Brix, respectively. The change in the TSS was non significant. Sandhu and Sindhu (1992) reported 13°Brix TSS in Grape: Mango (75:25) blends as against 10 and 13°Brix TSS in Kinnow: Mango: Pineapple (50:25:25) and Kinnow: Mango: Pear: Grape: (25:25:25:25), respectively. The TSS of RTS drink prepared in the above mentioned reports was kept at 14.1, 14.2, and 14.0, respectively. The results were found in conformity with the results observed in the present study.

The ash content of the blended beverage (control) and flavored blended beverage on zero day was 0.58 and 0.57 per cent, respectively. No appreciable change in the ash content was observed during the storage. The slight change in the ash content of blended beverage (control) and flavored blended beverage was assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial ash content of blended beverage (control) and flavored blended beverage was 0.58 and 0.57 per cent, respectively, which had no change upto 45 days of storage (0.58 and 0.57 per cent). The percentage of ash content of blended beverage (control) and flavored blended beverage after 60 and 75 days of storage was 0.59 and 0.58 per cent and showed non significant

change. The ash content of blended beverage (control) and flavored blended beverage upto 90 days of storage was 0.60 and 0.59 per cent from initial ash content 0.58 and 0.57, respectively. The change in the ash content was non significant.

The calcium content of the blended beverage (control) and flavored blended beverage on zero day was 98.67 and 96.61 mg/100g, respectively. A slight change in the calcium content of blended beverage (control) and flavored blended beverage was observed during storage. The changes in the calcium content of blended beverage (control) and flavored blended beverage was assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial calcium content of blended beverage (control) and flavored blended beverages was 98.67 and 96.61 mg/100g, respectively, which showed non significant changes upto 15 days. The value of calcium content of blended beverage (control) and flavored blended beverage upto 45 days was 98.68 and 96.62 mg/100g, respectively. The calcium content of blended beverage (control) and flavored blended beverage upto 75 days was increased to 98.69 and 96.63 mg/100g, respectively but the change was non significant. The calcium content of blended beverage (control) and flavored blended beverage upto 90 days was 98.69 and 96.64 mg/100g from initial calcium content of 98.67 and 96.61 mg/100g, respectively. No appreciable change in the calcium content was observed during the storage.

The phosphorus content of the blended beverage (control) and flavored blended beverage on zero day was 18.37 and 19.86 mg/100g, respectively. The changes in the phosphorus content of blended beverage (control) and flavored blended beverage was assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial phosphorus content of blended beverage (control) was 18.37 mg/100g, which had not changed upto 30 days (18.37 mg/100g) and showed non significant changes while the initial phosphorus content of flavored blended beverages was 19.86 mg/100g, which had not changed upto 15 days of storage. The change in the phosphorus content of beverage samples was non significant. The value of phosphorus content of blended beverage (control) upto 60 days was 18.38 mg/100g that was similar to the phosphorus content after 45 days storage (18.38 mg/100g) while the phosphorus

content of flavored blended beverage upto 60 days was 19.87 mg/100g that was similar to the phosphorus content after the 30 days storage (19.87 mg/100g). The phosphorus content in blended beverage (control) and flavored blended beverage after 90 days was 18.39 and 19.88 mg/100g, respectively. No appreciable change was observed in the phosphorus content during storage. The result showed that the phosphorus content was non significantly different in blended beverage (control) and flavored blended beverage during storage.

The total sugar of the blended beverage (control) and flavored blended beverage on zero day was 11.12 and 11.18 per cent, respectively. During the storage period the total sugar showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the total sugar of beverages were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial total sugar of blended beverage (control) and flavored blended beverage was 11.12 and 11.18 per cent, respectively, which had decreased to 10.86 and 11.04 per cent after 15 days of storage. The change in the total sugar of beverage samples was significantly different ($P \leq 0.05$). The percentage of total sugar of blended beverage (control) and flavored blended beverage after 30 days was decreased to 10.64 and 10.96, respectively. There was significant difference ($P \leq 0.05$) in the total sugar of the product during the storage period. The percentage of total sugar of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 10.54 and 10.74, respectively and showed a significant difference ($P \leq 0.05$). The percentage of total sugar of blended beverage (control) and flavored blended beverage after 60 days storage was 10.32 and 10.62, respectively. The results showed regular decline in total sugar. The decline in the total sugar may be due to the utilization by bacteria or conversion of sugar to other products during storage. The difference in the total sugar was significantly different ($P \leq 0.05$). The percentage of total sugar of blended beverage (control) and flavored blended beverage after 75 days of storage was 10.26 and 10.38, respectively and showed a significant difference ($P \leq 0.05$). The total sugar of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 10.18 and 10.26 per cent from initial total sugar content of 11.12 and 11.18 per cent. The change in the total

sugar was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.006).

The reducing sugar of the blended beverage (control) and flavored blended beverage on zero day was 4.94 and 4.70 per cent, respectively. A gradual increase in the reducing sugar of blended beverage (control) and flavored blended beverage was observed during the storage. The changes in the reducing sugar content of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial reducing sugar of blended beverage (control) and flavored blended beverage was 4.94 and 4.70 per cent, respectively, which had increased to 4.98 and 4.72 per cent after 15 days of storage. The change in the reducing sugar of beverage samples was significantly different (P≤ 0.05). The percentage of reducing sugar of blended beverage (control) and flavored blended beverage after 30 days was increased to 5.08 and 4.84, respectively. There was significant difference (P≤ 0.05) in the reducing sugar of the product during the storage period. The percentage of reducing sugar blended beverage (control) and flavored blended beverage after 45 days storage was 5.12 and 4.88, respectively and showed a significant difference (P≤ 0.05). The percentage of reducing sugar of blended beverage (control) and flavored blended beverage after 60 days storage was 5.18 and 4.92, respectively. The results showed regular increment in reducing sugar content. The percentage of reducing sugar was increased due to the conversion of non-reducing sugar to reducing sugar during storage. The difference in the reducing sugar was significantly different (P≤ 0.05). The percentage of reducing sugar of blended beverage (control) and flavored blended beverage after 75 days of storage was 5.26 and 5.04, respectively and showed a significant difference (P≤ 0.05). The reducing sugar content of blended beverage (control) and flavored blended beverage after 6 days of storage was increased to 5.30 and 5.08 per cent from initial reducing sugar content of 4.94 and 4.70 per cent. The change in the total sugar was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006 and 0.259). Shukla *et al.,* (2005) observed that the reducing sugars content of Whey-Apple juice beverage was increased from 3.76 to 4.25 per cent at refrigeration temperature after 6 months of storage. The results were found in conformity with the results observed in the present study.

The non reducing sugar of the blended beverage (control) and flavored blended beverage on zero day was 6.18 and 6.48 per cent, respectively. During the storage period the non reducing sugar showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the non reducing sugar of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.30b and 4.31b). The initial non reducing sugar of blended beverage (control) and flavored blended beverage was 6.18 and 6.48 per cent, respectively, which had decreased to 5.88 and 6.32 per cent after 15 days of storage. The change in the non reducing sugar of beverage samples was significantly different ($P \leq 0.05$). The percentage of non reducing sugar of blended beverage (control) and flavored blended beverage after 30 days was decreased to 5.56 and 6.12, respectively. There was significant difference ($P \leq 0.05$) in the non reducing sugar of the product during the storage period. The percentage of non reducing sugar of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 5.42 and 5.86, respectively and showed a significant difference ($P \leq 0.05$). The percentage of non reducing sugar of blended beverage (control) and flavored blended beverage after 60 days storage was 5.14 and 5.70, respectively. The results showed regular decline in non reducing sugar. The decline in the non reducing sugar may be due to the utilization by bacteria or conversion of sugar to other products during storage. The difference in the non reducing sugar was significantly different ($P \leq 0.05$). The percentage of non reducing sugar of blended beverage (control) and flavored blended beverage after 75 days of storage was 5.00 and 5.34, respectively and showed a significant difference ($P \leq 0.05$). The non reducing sugar of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 4.88 and 5.18 per cent from initial non reducing sugar content of 6.18 and 6.48 per cent. The change in the non reducing sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD= 0.008 and 0.022).

Table 4.30a: Changes in chemical constituents of blended beverage (control) during storage

Storage Period (Month)	Moisture %	Protein %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	82.76	0.65	25.75	0.51	3.60	12.2
15 Days	82.71	0.60	23.51	0.51	3.59	12.2
30 Days	82.69	0.59	21.28	0.52	3.50	12.3
45 Days	82.65	0.51	20.95	0.53	3.48	12.3
60 Days	82.61	0.48	18.51	0.53	3.47	12.4
75 Days	82.50	0.42	17.35	0.54	3.41	12.4
90 Days	82.42	0.40	16.70	0.55	3.38	12.4
CD (5%)	0.006	0.006	0.006	0.006	0.036	NS
P Value	0.00	0.00	0.00	0.00	0.00	0.08

Table 4.30b: Changes in chemical constituents of blended beverage (control) during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	0.58	98.67	18.37	11.12	4.94	6.18
15 Days	0.58	98.67	18.37	10.86	4.98	5.88
30 Days	0.58	98.68	18.37	10.64	5.08	5.56
45 Days	0.58	98.68	18.38	10.54	5.12	5.42
60 Days	0.59	98.69	18.38	10.32	5.18	5.14
75 Days	0.59	98.69	18.39	10.26	5.26	5.00
90 Days	0.60	98.69	18.39	10.18	5.30	4.88
CD (5%)	NS	NS	NS	0.006	0.006	0.008
P Value	0.15	0.08	0.08	0.00	0.00	0.00

Table 4.31a: Changes in chemical constituents of flavoured blended beverage during storage

Storage Period (Month)	Moisture %	Protein %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	82.60	0.68	28.75	0.48	3.72	12.0
15 Days	82.56	0.66	26.64	0.50	3.70	12.0
30 Days	82.52	0.64	24.86	0.51	3.69	12.4
45 Days	82.48	0.58	23.21	0.51	3.62	12.4
60 Days	82.44	0.54	20.84	0.52	3.58	12.6
75 Days	82.33	0.50	19.72	0.52	3.52	12.6
90 Days	82.25	0.48	18.36	0.53	3.44	12.8
CD (5%)	0.025	0.006	0.006	0.006	0.006	NS
P Value	0.00	0.00	0.00	0.00	0.00	0.48

Table 4.31b: Changes in chemical constituents of flavoured blended beverage during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	0.57	96.61	19.86	11.18	4.70	6.48
15 Days	0.57	96.61	19.86	11.04	4.72	6.32
30 Days	0.57	96.62	19.87	10.96	4.84	6.12
45 Days	0.57	96.62	19.87	10.74	4.88	5.86
60 Days	0.58	96.63	19.87	10.62	4.92	5.70
75 Days	0.58	96.63	19.88	10.38	5.04	5.34
90 Days	0.59	96.64	19.88	10.26	5.08	5.18
CD (5%)	NS	NS	NS	0.006	0.259	0.022
P Value	0.15	0.06	0.08	0.00	0.00	0.00

4.4.2.2 *Organoleptic evaluation*

The acceptability of blended beverage (control) and flavored blended beverage was evaluated by using ten members as per the standard procedure. The sensory feed back of beverage sample was taken on a 9 point hedonic scale (Appendix III), from panel members, on the different quality parameters (colour, flavour, taste and overall acceptability). The sensory receptors did not perceive any unfavorable change in quality throughout the storage. The data of the same was analysed to test the significant between the products (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

4.4.2.2.1 *Changes in the organoleptic qualities during storage*

The final product was stored for the determination of storage quality. The effect of storage on the organoleptic qualities of blended beverage (control) and flavored blended beverage was assessed during a storage period of 90 days with an interval of 15 days (Table 4.32 and 4.33).

The score for colour of blended beverage (control) and flavored blended beverage on zero day was 7.90 and 8.50, respectively. During the storage period the colour score showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the colour score of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.32 and 4.33). The initial sensory score for colour of blended beverage (control) and flavored blended beverage was 7.90 and 8.50, respectively, which had decreased to 7.85 and 7.60 after 15 days of storage. No appreciable change in the colour score was observed upto 15 days of storage. The sensory score for colour of blended beverage (control) after 30 days was decreased to 7.65 while the colour score of flavored blended beverage upto 30 days was 7.60, that was similar to the colour score after 15 days (7.60). There was significant difference ($P \leq 0.05$) in the colour score of the product during the storage period. The sensory score for colour of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 7.45 and 7.20, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for colour of blended beverage (control) and flavored blended beverage after 60 days storage was decreased to 7.25 and 7.00 and showed regular decline in colour score. The decline in the colour score may be due to the browning during storage. The

difference in the colour score was significantly different (P≤ 0.05). The sensory score for colour of blended beverage (control) and flavored blended beverage after 75 days of storage was 6.45 and 6.85, respectively. The colour score of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 6.40 and 6.80 from initial colour score of 7.90 and 8.50. The results showed the change in the colour score was significant at 5 per cent level of significance (CD = 0.227 and 0.212).

The score for flavour of blended beverage (control) and flavored blended beverage on zero day was 8.05 and 8.20, respectively. During the storage period the flavour score showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the flavour score of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.32 and 4.33). The initial sensory score for flavour of blended beverage (control) and flavored blended beverage was 8.05 and 8.20, respectively, which had decreased to 7.60 and 7.80 after 15 days of storage. No appreciable change in the flavour score was observed during storage. The sensory score for flavour of blended beverage (control) and flavored blended beverage after 30 days storage was decreased to 7.50 and 7.40, respectively and showed a significant difference (P≤ 0.05). The sensory score for flavour of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 7.35 and 6.90, respectively and showed a significant difference (P≤ 0.05). The sensory score for flavour of blended beverage (control) and flavored blended beverage after 60 days storage was decreased to 6.95 and 6.95 and showed regular decline in flavour score. The difference in the flavour score was significantly different (P≤ 0.05). The sensory score for flavour of blended beverage (control) and flavored blended beverage after 75 days of storage was 6.45 and 6.90, respectively and showed a significant difference (P≤ 0.05). The flavour score of blended beverage (control) after 90 days was similar to the flavour score after 75 days (6.45) and flavored blended beverage after 90 days of storage was decreased to 6.85. The results showed the change in the flavour score was significant at 5 per cent level of significance (CD = 0.196 and 0.215).

The score for taste of blended beverage (control) and flavored blended beverage on zero day was 8.10 and 7.90, respectively. During the storage period the

taste score showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the taste score of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.32 and 4.33). The initial sensory score for taste of blended beverage (control) was 8.10, which had decreased to 7.70 after 15 days storage, while the sensory score for taste of favored blended beverage was 7.90 that was similar to the taste score of initial days (7.90). No appreciable change in the taste score was observed upto 15 days storage. The sensory score for taste of blended beverage (control) and flavored blended beverage after 30 days was decreased to 7.35 and 7.25, respectively. There was significant difference ($P \leq 0.05$) in the taste score of the product during the storage period. The sensory score for taste of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 7.00 and 7.00, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for taste of blended beverage (control) and flavored blended beverage after 60 days storage was decreased to 6.55 and 6.50 and showed regular decline in taste scores. The difference in the taste score was significantly different. The sensory score for taste of blended beverage (control) and flavored blended beverage after 75 days of storage was 6.50 and 6.40, respectively. The taste score of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 6.45 and 6.20 from initial taste score of 8.10 and 7.90, respectively. The results showed the change in the taste score was significant at 5 per cent level of significance (CD = 0.197 and 0.293).

The score for overall acceptability of blended beverage (control) and flavored blended beverage on zero day was 8.02 and 8.19, respectively. During the storage period the overall acceptability score showed a declining trend in blended beverage (control) and flavored blended beverage. The changes in the overall acceptability score of beverage samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.32 and 4.33). The initial sensory score for overall acceptability of blended beverage (control) and flavored blended beverage was 8.02 and 8.19, respectively, which had decreased to 7.71 and 7.76 after 15 days of storage. No appreciable change in the overall acceptability score was observed during storage. The sensory score for overall acceptability of blended beverage (control) and flavored blended beverage after 30 days storage was decreased to 7.49 and 7.41, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for

overall acceptability of blended beverage (control) and flavored blended beverage after 45 days storage was decreased to 7.26 and 7.03, respectively and showed a significant difference ($P \leq 0.05$). The sensory score for overall acceptability of blended beverage (control) and flavored blended beverage after 60 days storage was decreased to 6.91 and 6.81 and showed regular decline in overall acceptability score. The difference in the overall acceptability score was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of blended beverage (control) and flavored blended beverage after 75 days of storage was 6.46 and 6.71, respectively and showed a significant difference ($P \leq 0.05$). The overall acceptability score of blended beverage (control) and flavored blended beverage after 90 days of storage was decreased to 6.43 and 6.61 from initial overall acceptability score of 8.02 and
8.19, respectively. The results showed the change in the overall acceptability score was significant at 5 per cent level of significance (CD = 0.167 and 0.206).

4.4.2.3 *Microbiological analysis*

Microbial food safety is an essential component of food quality. Quality is a combination of characteristics that have significance in determining the degree of acceptability of the product to a consumer. The microbial quality of the beverage samples was observed periodically. Microbiological changes were evaluated at the interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature (2-5°C).

The total plate count was nil at initial stage of storage. The effect of storage on the quality of beverages was assessed during a storage period of 90 days with an interval of 15 days (Table 4.34). Total plate counts were not observed upto 45 days of storage. Minimum total plate count in blended beverage (control) and flavored blended beverage was 8.0×10^2 and 9.0×10^2 cfu/ml, respectively after 90 days of storage. Yeast and mould counts in blended beverage (control) and flavored blended beverage were nil at initial days of storage. Yeast and mould counts were not recorded upto 45 days storage while after 90 days the yeast and mould count were 3.0×10^2 and 2.0×10^2 cfu/ml, respectively. Coliform count was found to be nil throughout the storage period. This indicated that the beverage remained safe microbiologically throughout the storage period and no appreciable change was observed during storage.

Table 4.32: Changes in sensory attributes in blended beverage (control) during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	7.90	8.05	8.10	8.02
15 Days	7.85	7.60	7.70	7.71
30 Days	7.65	7.50	7.35	7.49
45 Days	7.45	7.35	7.00	7.26
60 Days	7.25	6.95	6.55	6.91
75 Days	6.45	6.45	6.50	6.46
90 Days	6.40	6.45	6.45	6.43
CD (5%)	0.227	0.196	0.197	0.167
P Value	0.00	0.00	0.00	0.00

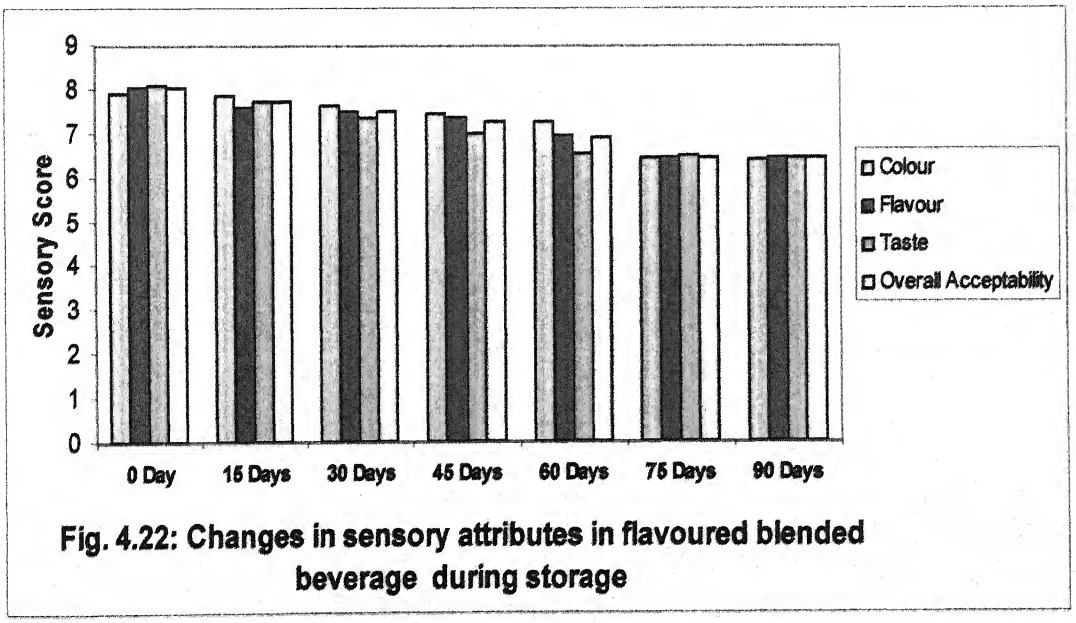


Fig. 4.22: Changes in sensory attributes in flavoured blended beverage during storage

Table 4.33: Changes in sensory attributes in flavoured blended beverage during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	8.50	8.20	7.90	8.19
15 Days	7.60	7.80	7.90	7.76
30 Days	7.60	7.40	7.25	7.41
45 Days	7.20	6.90	7.00	7.03
60 Days	7.00	6.95	6.50	6.81
75 Days	6.85	6.90	6.40	6.71
90 Days	6.80	6.85	6.20	6.61
CD (5%)	0.212	0.215	0.293	0.206
P Value	0.00	0.00	0.00	0.00

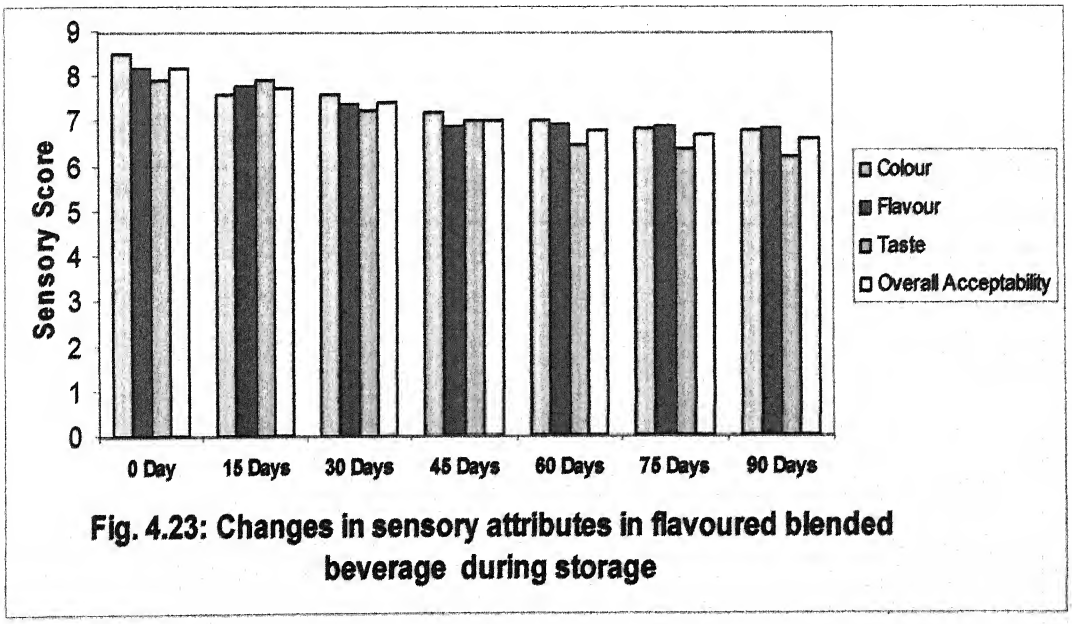


Fig. 4.23: Changes in sensory attributes in flavoured blended beverage during storage

Wood Apple blended beverage (control) and flavoured blended beverage was acceptable after 90 days at refrigeration temperature. Shukla *et al.* (2005) reported that the total plate count of whey-apple juice beverage increased with storage. Total plate count in whey-apple juice beverage was found 3.750 x 10^4 at refrigeration temperature after 6 months of storage. The data was found in conformity with the results observed in the present study.

Table 4.34: Microbial counts in Wood Apple blended beverage samples during storage

Treatments	Total Plate Counts		Yeast & Mould Counts	
	Blended Beverage (Control)	Flavored Blended Beverage	Blended Beverage (Control)	Flavored Blended Beverage
0 Day	0	0	0	0
15 Days	0	0	0	0
30 Days	0	0	0	0
45 Days	0	0	0	0
60 Days	4.5×10^1	4.0×10^1	1.5×10^1	2.5×10^1
75 Days	7.0×10^2	6.5×10^2	2.0×10^2	1.5×10^2
90 Days	8.0×10^2	9.0×10^2	3.0×10^2	2.0×10^2
CD (5%)	0.435	0.435	0.435	0.435
P Value	0.00	0.00	0.00	0.00

4.5 PREPARATION OF THE WOOD APPLE JUICE BASED CARBONATED DRINK

4.5.1 Standardization of the Parameters

4.5.1.1 *Standardization of Wood Apple pulp percentage*

Wood Apple pulp was used for the preparation of carbonated drink. The carbonated drink was prepared by standard method. The percentage of Wood Apple pulp in the carbonated drink was standardized by incorporation of 20, 25 and 30 per cent pulp (Table 4.35). The sensory score for 20, 25 and 30 per cent Wood Apple pulp in carbonated drink was 6.56, 7.78 and 6.85, respectively. The carbonated drink made of 20 per cent Wood Apple pulp was found highest score (7.78) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.003). The best score for 20 per cent Wood Apple pulp was due to the more acceptable colour and taste. The taste of the 30 per cent Wood Apple pulp was more acidic in nature. The taste of 10 per cent pulp in carbonated drink was very low due to low concentration of Wood Apple pulp.

4.5.1.2 *Standardization of sugar percentage*

Sugar content was standardized by incorporation of 10, 15 and 20 per cent sugar (Table 4.36). The sensory score for 10, 15 and 20 per cent sugar was 6.43, 7.56, and 6.76, respectively. The sensory score for 15 per cent sugar was found highest (7.56) and this was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.299). The best score for 15 per cent sugar was due to low sweetness of 10 per cent sugar while very high sweetness for 20 per cent sugar content. The sugar content of 15 per cent was selected for further study.

Table 4.35: Standardization of the percentage of Wood Apple pulp for wood apple based carbonated drink

Treatment	Colour	Flavour	Taste	Overall Acceptability
WAP(20%)	6.60	6.60	6.50	6.56
WAP(25%)	8.20	7.50	7.66	7.78
WAP(30%)	6.95	7.10	6.50	6.85
CD (5%)	0.511	NS	0.518	0.363
P value	0.00	0.17	0.00	0.00

Table 4.36: Standardization of the percentage of sugar for Wood Apple based carbonated drink

Treatment	Colour	Flavour	Taste	Overall Acceptability
Sugar (10%)	6.70	6.60	6.00	6.43
Sugar (15%)	7.60	7.50	7.50	7.56
Sugar (20%)	6.90	6.70	6.70	6.76
CD (5%)	0.311	0.455	0.460	0.299
P value	0.01	0.05	0.00	0.00

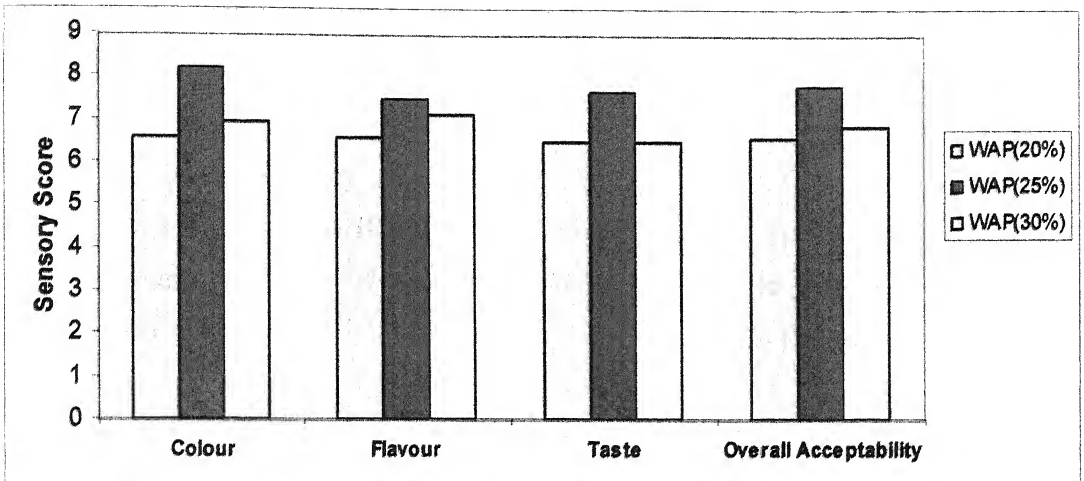


Fig. 4.24: Standardization of the percentage of Wood Apple pulp in Wood Apple carbonated drink

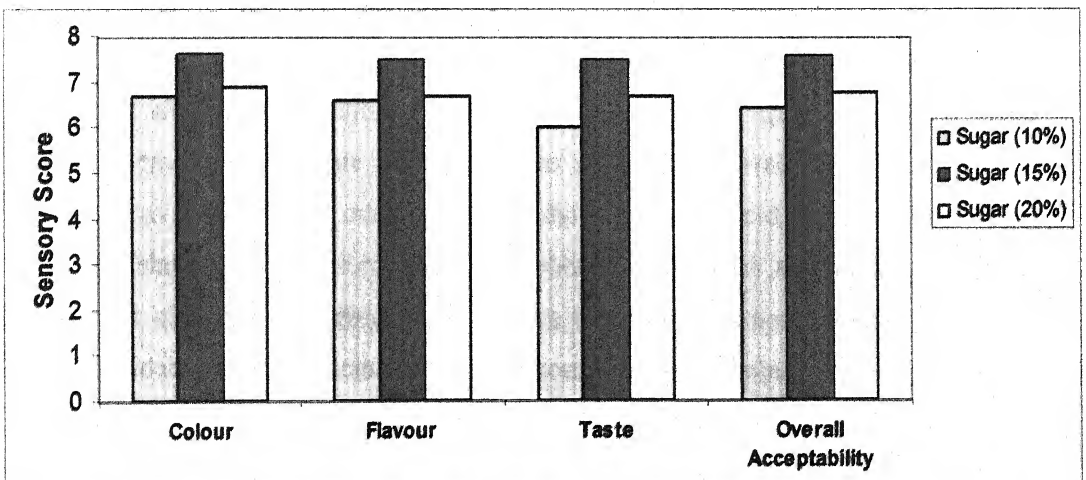


Fig. 4.25: Standardization of the percentage of sugar in Wood Apple carbonated drink

4.5.1.3 *Standardization of the time of carbonation*

The time of carbonation was standardized by dissolving 2, 3 and 4 minute carbon dioxide gas into the carbonated drink. The sensory score for 2, 3 and 4 min carbon dioxide gas in carbonated drink was 6.33, 7.10 and 6.89, respectively (Table 4.37). The sensory score for 3 min carbon dioxide gas was found highest (7.10) and this was non significantly different. The best score for 3 min carbonation was due to the mild taste of 2 min of carbonation while very intense taste for 4 min of carbonation.

4.5.2 Storage Study

The Wood Apple carbonated drink was stored for the storage study. The Wood Apple carbonated drink was filled in sterilized glass bottles and stored at refrigeration temperature (2-5°C) for 90 days. Physico-chemical characteristics were evaluated at an interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature and physico-chemical, organoleptic, and microbiological changes were observed.

4.5.2.1 *Physico-chemical characteristics*

The chemical constituents present in Wood Apple fruit influence the nutritional and storage qualities of the product. The Wood Apple carbonated drink was analysed for proximate composition as per the approved methods. Moisture content was analysed by oven drying method, ascorbic acid content by titration method using (2, 6, dichlorophenol indophenol dye), total ash, total acidity (as anhydrous citric acid), carbohydrate, sugars (Lane and Eynon, 1923), protein by micro-kjeldahl method, calcium and phosphorus were determined by the procedures described by Ranganna (2003). The pH of the carbonated drink was determined by pH meter while total soluble solids (TSS) were determined by hand Refractometer (Ranganna, 1986). All constituents were analysed at 0, 15, 30, 45, 60, 75 and 90 days of storage at refrigeration temperature (2-5°C).

Table 4.37: Standardization of the time of carbonation

Treatment	Colour	Flavour	Taste	Overall Acceptability
Time (2 min)	6.60	6.40	6.00	6.33
Time (3 min)	6.80	7.00	7.50	7.10
Time (4 min)	6.80	6.80	7.00	6.86
CD (5%)	NS	NS	0.579	NS
P value	0.90	0.49	0.03	0.08

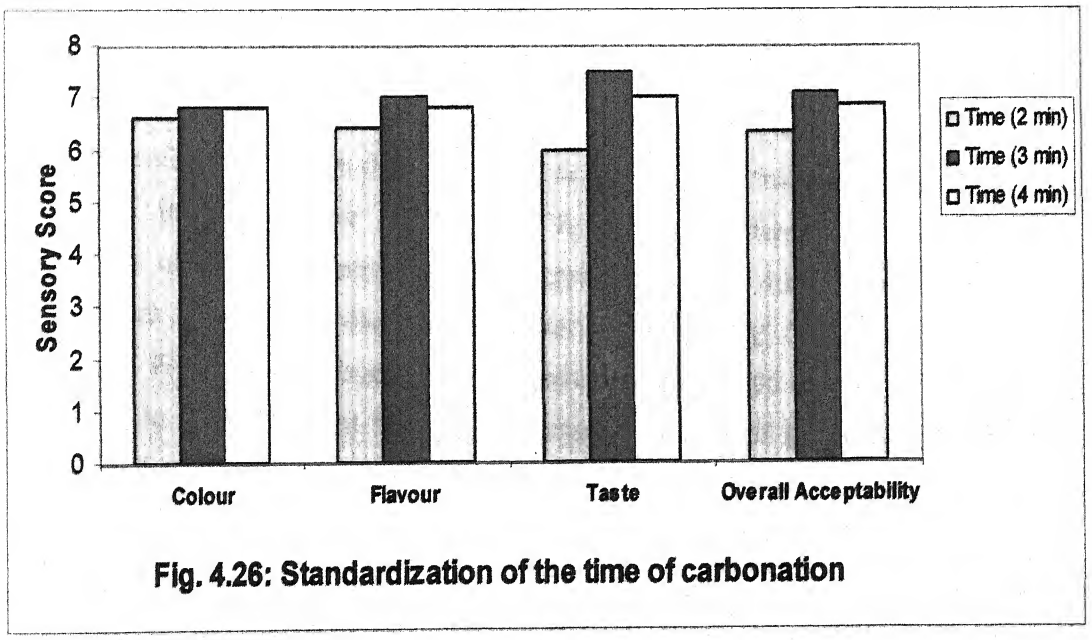


Fig. 4.26: Standardization of the time of carbonation

4.5.2.1.1 *Physico-chemical changes*

The product was stored for 90 days and the changes in moisture, protein, ascorbic acid, acidity, pH, TSS, ash, sugars and minerals were observed. The results of the observations are presented in Table 4.38.

The result showed a decrease in moisture content of sample with increase in the storage period. The moisture content of the Wood Apple carbonated drink on zero day was 86.16 per cent. The change in the moisture content of Wood Apple carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The moisture content of Wood Apple carbonated drink after 15 days of storage was 86.01 per cent from initial moisture content 86.16 per cent. There was significant change ($P \leq 0.05$) in the moisture content. The percentage of moisture content of Wood Apple Wood Apple carbonated drink after 30 days was decreased to 85.97. There was significant difference ($P \leq 0.05$) in the moisture content of the product during the storage period. The percentage of moisture content of Wood Apple carbonated drink after 45 days storage was decreased to 85.93 and showed a significant difference ($P \leq 0.05$). The percentage of moisture content of Wood Apple Wood Apple carbonated drink after 60 days storage was 85.91. The results showed regular decline in moisture content. The decline in the moisture content may be due to the evaporation of moisture from Wood Apple carbonated drink during storage. The difference in the moisture content was significantly different ($P \leq 0.05$). The percentage of moisture content of Wood Apple carbonated drink after 75 days of storage was 85.87 and showed a significant difference ($P \leq 0.05$). The moisture content of Wood Apple Wood Apple carbonated drink after 90 days of storage was decreased to 85.85 per cent from initial moisture content of 86.16 per cent. The change in the moisture content was highly significant ($P = 0.000$) at 5 per cent level of significance ($CD = 0.006$).

The protein content of the Wood Apple carbonated drink on zero day was 0.79 per cent. During the storage period the protein content showed a declining trend in Wood Apple carbonated drink. The change in the protein content of Wood Apple carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The protein content of Wood Apple carbonated drink after 15 days of storage was decreased to 0.78 per cent from initial protein content of 0.79 per

cent. The change in the protein content of Wood Apple carbonated drink was significantly different (P≤ 0.05). The percentage of protein content of Wood Apple carbonated drink after 30 days was 0.76. There was significant difference (P≤ 0.05) in the protein content of the product during the storage period. The percentage of protein content of Wood Apple carbonated drink after 45 days storage was decreased to 0.74 and showed a significant difference (P≤ 0.05). The percentage of protein content of Wood Apple carbonated drink after 60 days storage was 0.70. The results showed regular decline in protein content. The difference in the protein content was significantly different (P≤ 0.05). The percentage of protein content of Wood Apple carbonated drink after 75 days of storage was 0.68 and showed a significant difference (P≤ 0.05). The protein content of Wood Apple carbonated drink after 90 days of storage was decreased to 0.66 per cent from initial protein content of 0.79 per cent. The change in the protein content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006).

The ascorbic acid content of the Wood Apple carbonated drink on zero day was 22.54 mg/100g. During the storage period the ascorbic acid content showed a declining trend in Wood Apple carbonated drink. The change in the ascorbic acid content of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The ascorbic acid content of Wood Apple carbonated drink after 15 days of storage was decreased to 20.48 mg/100g from initial ascorbic acid content of 22.54 mg/100g. The change in the ascorbic acid content of carbonated drink was significantly different (P≤ 0.05). The value of ascorbic acid content of Wood Apple carbonated drink after 30 days was 18.75 mg/100g. There was significant difference (P≤ 0.05) in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of Wood Apple carbonated drink after 45 days storage was decreased to 18.27 mg/100g and showed a significant difference (P≤ 0.05). The value of ascorbic acid content of Wood Apple carbonated drink after 60 days storage was 17.88 mg/100g. The results showed regular decline in ascorbic acid content. The decline in the ascorbic acid content may be due to the depletion of ascorbic acid during storage. The difference in the ascorbic acid content was significantly different (P≤ 0.05). The value of ascorbic acid content of Wood Apple carbonated drink after 75 days of storage was 17.22 mg/100g and showed a significant difference (P≤ 0.05). The ascorbic acid content of Wood Apple carbonated

drink after 90 days of storage was decreased to 16.93 mg/100g from initial ascorbic acid content of 22.54 mg/100g. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 mg/100gm level of significance (CD = 0.006). The ascorbic acid content in Aonla fruit based carbonated health drink was decreased from 48.01 to 23.50 mg/100g at cold storage during 90 days of storage period observed by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

The acidity of the Wood Apple carbonated drink on zero day was 0.28 per cent. No appreciable change in the acidity of Wood Apple carbonated drink was observed during the storage. The change in the acidity of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The acidity of Wood Apple carbonated drink on 15 day of storage was 0.28 per cent that was similar to the acidity content at zero day (0.28 per cent). There was non significant change in the acidity. The percentage of acidity of Wood Apple carbonated drink after 30 days was 0.29 per cent and after 45 days of storage was 0.30 per cent. The change in the acidity was significant ($P \leq 0.05$). The acidity content upto 75 days of storage was 0.32 per cent that was similar to the acidity content after 60 days of storage (0.32 per cent). The percentage of acidity of Wood Apple carbonated drink after 90 days of storage was increased to 0.33 and showed a significant difference ($P \leq 0.05$). The slight change in the acidity might be due to the concentration of the product due to evaporation of the moisture during storage. The acidity of Aonla fruit based carbonated health drink was decreased from 0.24 to 0.21 per cent in cold storage during 90 days of storage as reported by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

The result showed a decrease in pH value of sample with increase in the storage period. The pH of the Wood Apple carbonated drink on zero day was 3.44. The change in the pH content of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The pH of Wood Apple carbonated drink upto 15 days of storage was 3.44 that was similar to the pH at zero day (3.44). There was non significant change in the pH. The value of pH of Wood Apple carbonated drink after 30 days was decreased to 3.40 and showed a significant change ($P \leq 0.05$). The value of pH of Wood Apple carbonated drink after 45 days

storage was decreased to 3.35 and showed a significance difference (P≤ 0.05). The value of pH of Wood Apple carbonated drink after 60 days storage was 3.23. The results showed regular decline in pH. The difference in the pH was significantly different (P≤ 0.05). The value of pH of Wood Apple carbonated drink after 75 days of storage was 3.20 and showed a significant difference (P≤ 0.05). The pH of Wood Apple carbonated drink after 90 days of storage was decreased to 3.18 from initial pH of 3.44. The change in the pH was significant (P= 0.00) at 5 per cent level of significance (CD = 0.035). The pH value was increased from 2.88 to 3.20 in Aonla fruit based carbonated health drink at cold storage during 90 days of storage period reported by Thorat *et al.* (2007). The results were found in conformity with the results observed in the present study.

The TSS of the Wood Apple carbonated drink on zero day was 12.2°Brix. A gradual increase in the TSS of Wood Apple carbonated drink was observed during storage. The change in the TSS of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38a). The TSS of Wood Apple carbonated drink upto 15 days of storage was 12.2°Brix, that was similar to the TSS content at zero day (12.2°Brix). The change in the TSS content of carbonated drink was non significant. The value of TSS of Wood Apple carbonated drink after 30 days was increased to 12.4°Brix. There was significant difference (P≤ 0.05) in the TSS content of the product during the storage period. The value of TSS of Wood Apple carbonated drink after 45 days storage was increased to 12.6°Brix and showed a significant difference (P≤ 0.05). The value of TSS of Wood Apple carbonated drink after 60 days storage was 12.8°Brix. The results showed regular increase in TSS. The increment in the TSS may be due to increase in soluble solid content. The difference in the TSS content was significantly different (P≤ 0.05). The value of TSS of Wood Apple carbonated drink after 75 days of storage was 13.0°Brix and showed a significant difference (P≤ 0.05). The TSS content of Wood Apple carbonated drink after 90 days of storage was increased to 13.2°Brix from initial TSS of 12.2°Brix. The change in the TSS was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.061). Thorat *et al.* (2007) observed that the TSS content increased from 12.80 to 16.38°Brix in Aonla fruit based carbonated health drink at cold storage during 90 days of storage period. The results were found in conformity with the results observed in the present study.

The ash content of the Wood Apple carbonated drink on zero day was 0.41 per cent. No appreciable change in the ash content was observed during the storage. The change in the ash content of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The ash content of Wood Apple carbonated drink upto 30 days of storage was 0.41 per cent that was similar to the ash content at zero day (0.41 per cent). The percentage of ash content of Wood Apple carbonated drink after 45 and 60 days of storage was 0.42 and showed non significance difference. The percentage of ash content of Wood Apple carbonated drink after 75 and 90 days of storage was 0.28. The change in the ash content was non significant. The slight change might be due to change in moisture in the product.

The calcium content of the Wood Apple carbonated drink on zero day was 99.70 mg/100g. The slight change in the calcium content of Wood Apple carbonated drink was observed during storage. The change in the calcium content of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The calcium content of Wood Apple carbonated drink upto 30 days of storage was 99.70 mg/100g that was similar to the calcium content at zero day (99.70 mg/100g). There was non significant change in the calcium content. The value of calcium content of Wood Apple carbonated drink after 45 and 60 days of storage was 99.71 mg/100g and showed a non significant change during storage. The value of calcium content of Wood Apple carbonated drink upto 90 days of storage was 99.72 mg/100g that was similar to the calcium content at 75 days storage (99.72 mg/100g) and showed non significance difference.

The phosphorus of the Wood Apple carbonated drink on zero day was 19.01 mg/100g. No appreciable changes were observed in the phosphorus content of Wood Apple carbonated drink during storage. The change in the phosphorus of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The phosphorus content of Wood Apple carbonated drink upto 15 days of storage was 19.01 mg/100g from initial phosphorus content of 19.01 mg/100g. The change in the phosphorus content of carbonated drink was non significant. The value of phosphorus of Wood Apple carbonated drink upto 45 days was increased to 19.02 mg/100g that was similar to the phosphorus content after 30 days of storage (19.02

mg/100g). There was non significant difference in the phosphorus content. The value of phosphorus content of Wood Apple carbonated drink upto 90 days of storage was increased to 19.03 mg/100g. The result showed a non significant difference in phosphorus content during 90 days of storage.

The total sugar of the Wood Apple carbonated drink on zero day was 5.68 per cent. A gradual increase in the total sugar of Wood Apple carbonated drink was observed during the storage. The change in the total sugar of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The total sugar of Wood Apple carbonated drink after 15 days of storage was 5.94 per cent from initial total sugar of 5.68 per cent. The change in the total sugar of carbonated drink was significantly different ($P \leq 0.05$). The value of total sugar of Wood Apple carbonated drink after 30 days was increased to 6.20 per cent. There was significant difference ($P \leq 0.05$) in the total sugar of the product during the storage period. The value of total sugar of Wood Apple carbonated drink after 45 days storage was increased to 6.74 per cent and showed a significant difference ($P \leq 0.05$). The value of total sugar of Wood Apple carbonated drink after 60 days storage was 6.98 per cent. The results showed regular increment in total sugar. The increase in total sugars during storage has been attributed to inversion of disaccharide under acidic conditions The difference in the total sugar was significantly different ($P \leq 0.05$). The value of total sugar of Wood Apple carbonated drink after 75 days of storage was 7.38 per cent and showed a significant difference ($P \leq 0.05$). The total sugar of Wood Apple carbonated drink after 90 days of storage was increased to 7.86 per cent from initial total sugar content of 4.78 per cent. The change in the total sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.025). The total sugar of Aonla fruit based carbonated health drink was increased from 9.99 to 14.49 per cent at cold storage after 90 days of storage period reported by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

The reducing sugar of the Wood Apple carbonated drink on zero day was 3.48 per cent. A gradual increase in the reducing sugar of Wood Apple carbonated drink was observed during the storage. The change in the reducing sugar of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The reducing sugar of Wood Apple carbonated drink after 15 days of

storage was 3.56 per cent from initial reducing sugar of 3.48 per cent. The change in the reducing sugar of carbonated drink was significantly different (P≤ 0.05). The value of reducing sugar of Wood Apple carbonated drink after 30 days was increased to 3.62 per cent. There was significant difference (P≤ 0.05) in the reducing sugar of the product during the storage period. The value of reducing sugar of Wood Apple carbonated drink after 45 days storage was increased to 3.78 per cent and showed a significant difference (P≤ 0.05). The value of reducing sugar of Wood Apple carbonated drink after 60 days storage was 3.98 per cent. The results showed regular increment in reducing sugar. The increase in reducing sugars during storage has been attributed to inversion of disaccharide under acidic conditions. The difference in the reducing sugar was significantly different (P≤ 0.05). The value of reducing sugar of Wood Apple carbonated drink after 75 days of storage was 4.02 per cent and showed a significant difference (P≤ 0.05). The reducing sugar of Wood Apple carbonated drink after 90 days of storage was increased to 4.24 per cent from initial reducing sugar content of 3.48 per cent. The change in the reducing sugar was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.006). Thorat *et al.* (2007) observed that the reducing sugar was increased from 9.31 to 11.31 per cent in Aonla fruit based carbonated health drink at cold storage during 90 days of storage period. The results were found in conformity with the results observed in the present study.

The non reducing sugar of the Wood Apple carbonated drink on zero day was 2.20 per cent. A gradual increase in the non reducing sugar of Wood Apple carbonated drink was observed during the storage. The change in the non reducing sugar of carbonated drink was assessed during the storage period of 90 days with an interval of 15 days (Table 4.38b). The non reducing sugar of Wood Apple carbonated drink after 15 days of storage was 2.38 per cent from initial non reducing sugar of 2.20 per cent. The change in the non reducing sugar of carbonated drink was significantly different (P≤ 0.05). The value of non reducing sugar of Wood Apple carbonated drink after 30 days was increased to 2.58 per cent. There was significant difference (P≤ 0.05) in the non reducing sugar of the product during the storage period. The value of non reducing sugar of Wood Apple carbonated drink after 45 days storage was increased to 2.96 per cent and showed a significant difference (P≤ 0.05). The value of non reducing sugar of Wood Apple carbonated drink after 60 days

storage was 3.00 per cent. The results showed regular increment in non reducing sugar. The increase in non reducing sugars during storage has been attributed to inversion of disaccharide under acidic conditions. The difference in the non reducing sugar was significantly different ($P \leq 0.05$). The value of non reducing sugar of Wood Apple carbonated drink after 75 days of storage was 3.36 per cent and showed a significant difference ($P \leq 0.05$). The non reducing sugar of Wood Apple carbonated drink after 90 days of storage was increased to 3.62 per cent from initial non reducing sugar content of 2.20 per cent. The change in the non reducing sugar was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.023). The non reducing sugar was increased from 0.68 to 3.18 per cent in Aonla fruit based carbonated health drink at cold storage during 90 days of storage period was reported by Thorat *et al.* (2007). The datas were found in conformity with the results observed in the present study.

Table 4.38a: Changes in chemical constituents of wood apple based carbonated drink during storage

Storage Period (Month)	Moisture %	Protein %	Ascorbic Acid (mg/100g)	Acidity %	PH %	TSS (°Brix)
0 Day	86.16	0.79	22.54	0.28	3.44	12.2
15 Days	86.01	0.78	20.48	0.28	3.44	12.2
30 Days	85.97	0.76	18.75	0.29	3.40	12.4
45 Days	85.93	0.74	18.27	0.30	3.35	12.6
60 Days	85.91	0.70	17.88	0.32	3.23	12.8
75 Days	85.87	0.68	17.22	0.32	3.20	13.0
90 Days	85.85	0.66	16.93	0.33	3.18	13.2
CD (5%)	0.006	0.006	0.006	0.006	0.035	0.061
P value	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.38b: Changes in chemical constituents of wood apple based carbonated drink during storage

Storage Period (Month)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
0 Day	0.41	99.70	19.01	5.68	3.48	2.20
15 Days	0.41	99.70	19.01	5.94	3.56	2.38
30 Days	0.41	99.70	19.02	6.20	3.62	2.58
45 Days	0.42	99.71	19.02	6.74	3.78	2.96
60 Days	0.42	99.71	19.03	6.98	3.98	3.00
75 Days	0.43	99.72	19.03	7.38	4.02	3.36
90 Days	0.43	99.72	19.03	7.86	4.24	3.62
CD (5%)	NS	NS	NS	0.025	0.006	0.023
P value	0.08	0.99	0.08	0.00	0.00	0.00

4.5.2.2 *Organoleptic evaluation*

The acceptability of Wood Apple carbonated drink was evaluated by a ten member panel. The sensory feed back of Wood Apple based carbonated drink was taken on a 9 point hedonic scale (Appendix IV), from panel members, on the different quality parameters (colour, flavour, taste and overall acceptability). The data of the same was analysed to test the significance between the products (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

4.5.2.2.1 *Changes in the organoleptic qualities during storage*

The final product was stored for the determination of storage quality. The effect of storage on the organoleptic qualities of Wood Apple carbonated drink was assessed during a storage period of 90 days with an interval of 15 days (Table 4.39).

The score for colour of Wood Apple carbonated drink on zero day was 8.10. During the storage period the colour score showed a declining trend in Wood Apple carbonated drink. The changes in the colour score of carbonated drink samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.39). The initial sensory score for colour of Wood Apple carbonated drink was 8.10, which had decreased to 7.55 after 15 days. The change in the colour score of carbonated drink was significantly different ($P \leq 0.05$). The sensory score for colour of Wood Apple carbonated drink after 30 days was decreased to 7.50. There was significant difference ($P \leq 0.05$) in the colour score of the carbonated drink during the storage period. The sensory score for colour of Wood Apple carbonated drink after 45 days storage was decreased to 6.95 and showed a significant difference ($P \leq 0.05$). The sensory score for colour of Wood Apple carbonated drink after 60 days storage was decreased to 6.85 and showed regular decline in colour score. The sensory score for colour of Wood Apple carbonated drink after 75 days of storage was 6.80. The colour score of Wood Apple carbonated drink after 90 days was decreased to 6.65 from initial colour score 8.10. The results showed the change in the colour score was significant at 5 per cent level of significance (CD = 0.227). No appreciable changes were observed after the 90 days of storage. The initial colour score of Aonla fruit based carbonated health drink was 9.0 which had decreased to 7.9 after 90 days of storage described by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

The score for flavour of Wood Apple carbonated drink on zero day was 7.80. During the storage period the flavour score showed a declining trend in Wood Apple carbonated drink. The changes in the flavour score of carbonated drink samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.39). The initial sensory score for flavour of Wood Apple carbonated drink was 7.80, which had decreased to 7.10 after 15 days. The change in the flavour score of carbonated drink was significantly different ($P \leq 0.05$). The sensory score for flavour of Wood Apple carbonated drink upto 30 days was 7.10 that was similar to the sensory score after 15 days of storage (7.10) and showed non significant change. The sensory score for flavour of Wood Apple carbonated drink upto 60 days was 6.50 that was similar to the colour score after 45 days storage (6.50). The sensory score for flavour of Wood Apple carbonated drink after 75 days of storage was 6.45 and showed regular decline during storage. The flavour score of Wood Apple carbonated drink after 90 days of storage was decreased to 6.40 from initial flavour score of 7.80. The results showed the change in the flavour score was significant at 5 per cent level of significance (CD = 0.207). The result showed some non acceptable changes were observed after the 75 days of storage. Thorat *et al.* (2007) observed that the flavour score of Aonla fruit based carbonated health drink was decreased from 8.6 to 7.8 after 90 days of storage. The data was found in conformity with the results observed in the present study.

The score for taste of Wood Apple carbonated drink on zero day was 7.70. During the storage period the taste score showed a declining trend in Wood Apple carbonated drink. The changes in the taste score of carbonated drink samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.39). The initial sensory score for taste of Wood Apple carbonated drink was 7.70, which had decreased to 7.45 after 15 days. The change in the taste score of carbonated drink was significantly different ($P \leq 0.05$). The sensory score for taste of Wood Apple carbonated drink after 30 days was 6.90 and showed significant difference ($P \leq 0.05$). The sensory score for taste of Wood Apple carbonated drink after 45 days storage was decreased to 6.50 and showed a significant difference ($P \leq 0.05$). The sensory score for taste of Wood Apple carbonated drink after 60 days storage was decreased to 6.40 and showed regular decline in taste score. The decline in the taste score may be due to the change in the sugar and fat during storage. The sensory score for taste of Wood Apple carbonated drink after 75 days of storage was 6.20 and showed a significant difference ($P \leq 0.05$). The taste score of Wood Apple carbonated drink upto 90 days

was similar to the taste score after 75 days of storage (6.20). The taste score after 90 days was decreased to 6.20 from initial taste score of 7.70. The results showed the change in the taste score was significant at 5 per cent level of significance (CD = 0.228). The taste of Wood Apple carbonated drink was not acceptable after the 75 days of storage. The taste score of Aonla fruit based carbonated health drink was decreased from 8.5 to 7.6 during 90 days of storage reported by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

The score for overall acceptability of Wood Apple carbonated drink on zero day was 7.86. During the storage period the overall acceptability score showed a declining trend in Wood Apple carbonated drink. The changes in the overall acceptability score of carbonated drink samples were assessed during the storage period of 90 days with an interval of 15 days (Table 4.39). The initial sensory score for overall acceptability of Wood Apple carbonated drink was 7.86, which had decreased to 7.36 after 15 days. The change in the overall acceptability score of carbonated drink was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple carbonated drink after 30 days was decreased to 7.16. There was significant difference ($P \leq 0.05$) in the overall acceptability score of the carbonated drink during the storage period. The sensory score for overall acceptability of Wood Apple carbonated drink after 45 days storage was decreased to 6.65 and showed a significant difference ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple carbonated drink after 60 days storage was decreased to 6.58 and showed regular decline in overall acceptability score. The difference in the overall acceptability score was significantly different ($P \leq 0.05$). The sensory score for overall acceptability of Wood Apple carbonated drink after 75 days of storage was 6.48. The overall acceptability score of Wood Apple carbonated drink after 90 days of storage was decreased to 6.41 from initial overall acceptability score of 7.86. The results showed the change in the overall acceptability score was significant at 5 per cent level of significance (CD = 0.154). Some non acceptable changes were observed after the 90 days of storage. The initial score for overall acceptability of Aonla fruit based carbonated health drink was 8.8 which had decreased to 7.4 during 90 days of storage described by Thorat *et al.* (2007). The data was found in conformity with the results observed in the present study.

Table 4.39: Changes in sensory attributes in carbonated drink during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	8.10	7.80	7.70	7.86
15 Days	7.55	7.10	7.45	7.36
30 Days	7.50	7.10	6.90	7.16
45 Days	6.95	6.50	6.50	6.65
60 Days	6.85	6.50	6.40	6.58
75 Days	6.80	6.45	6.20	6.48
90 Days	6.65	6.40	6.20	6.41
CD (5%)	0.227	0.207	0.228	0.154
P value	0.00	0.00	0.00	0.00

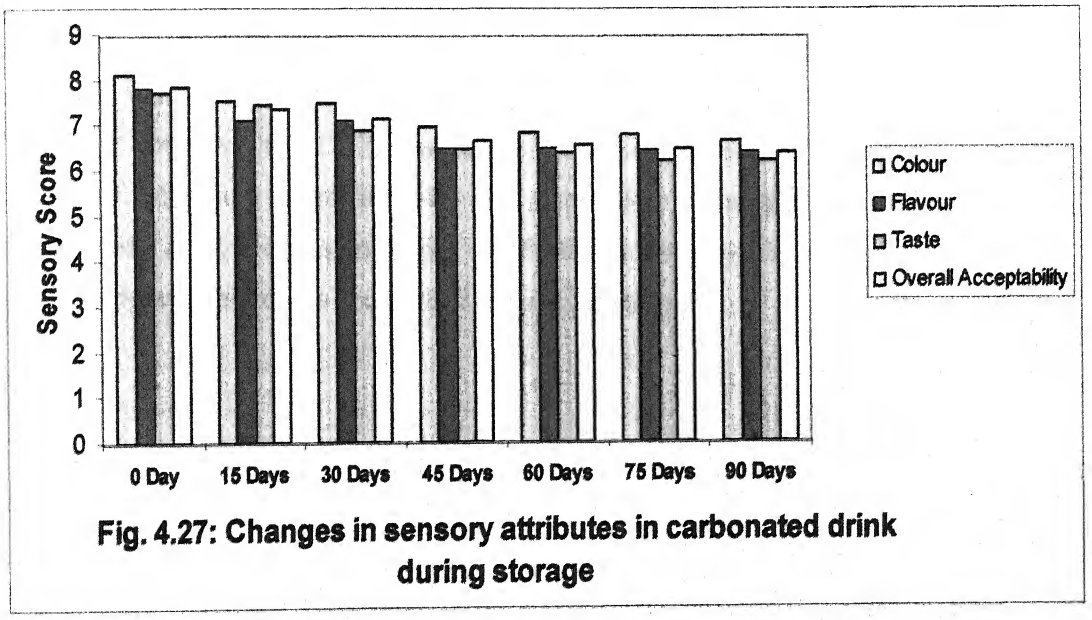


Fig. 4.27: Changes in sensory attributes in carbonated drink during storage

4.5.2.3 *Microbiological analysis*

Microbial food safety is an essential component of food quality. Quality is a combination of characteristics that have significance in determining the degree of acceptability of the product to a consumer. The microbial quality of the Wood Apple carbonated drink was observed periodically. Microbiological changes were evaluated at the interval of 0, 15, 30, 45, 60, 75 and 90 days during storage at refrigeration temperature (2-5°C).

The total plate count was nil at initial stage of storage. The effect of storage on the quality of Wood Apple carbonated drink was assessed during a storage period of 90 days with an interval of 15 days (Table 4.40). Total plate counts were not observed upto 45 days of storage. Total plate count in Wood Apple carbonated drink was found 7.0×10^2 cfu/ml after 90 days of storage. Yeast and mould counts in Wood Apple carbonated drink were nil at initial days of storage. Yeast and mould counts were not recorded upto 60 days storage while after 90 days the yeast and mould count were 1.5×10^2 cfu/ml. Coliform count was found to be nil throughout the storage period at refrigeration temperature. This indicated that the Wood Apple carbonated drink remained safe microbiologically throughout the storage period and no appreciable change was observed during storage. Wood Apple carbonated drink was acceptable after 90 days at refrigeration temperature. Thorat *et al.* (2007) reported that the microbial count was nil at initial stage of storage but increased as the storage period advanced. Minimum microbial count was recorded in carbonated Aonla fruit juice based health drink at cold storage (6×10^3cfu/ml) after 90 days. The data was found in conformity with the results observed in the present study.

Table 4.40: Microbial counts in Wood Apple carbonated drink during storage

Treatments	Total Plate Counts	Yeast & Mould Counts
0 Day	0	0
15 Days	0	0
30 Days	0	0
45 Days	0	0
60 Days	1.0×10^1	0
75 Days	2.0×10^2	4.0×10^1
90 Days	7.0×10^2	1.5×10^2
CD (5%)	0 .435	0.355
P value	0.00	0.00

4.6 PREPARATION OF THE WOOD APPLE POWDER

4.6.1 Standardization of the Parameters

4.6.1.1 *Standardization of the temperature for drying*

Wood Apple pulp was used for the preparation of powder. The Wood Apple pulp was dried at four different temperatures 50, 60, 70 and 80°C. The sensory score for 50, 60, 70 and 80°C powder was 6.75, 7.48, 6.75 and 6.30, respectively (Table 4.41). The powder dried at 60°C was found to set highest score (7.48) and this was significantly different ($P \leq 0.05$) in comparison to other drying temperatures (CD = 0.308). The best score for 60°C drying temperature was due to the more acceptable colour and taste. The sensory score of the Wood Apple powder dried at 50°C took long time in drying, drying was not proper. Powder was dried at 70 and 80°C was dark in colour. The powder dried at 80°C gave burning flavour than other powder. The drying temperature of 60°C was selected for further study.

4.6.1.2 Standardization of the percentage of preservative (KMS)

The Wood Apple pulp was treated with three different percentages of preservative (KMS) 0.1, 0.3, and 0.5 per cent and dried at pre standardized temperature of 60°C. The sensory score for 0.1, 0.3 and 0.5 per cent KMS was 6.73, 7.65 and 6.68, respectively (Table 4.42). The Wood Apple powder treated with 0.3 per cent KMS was found best and gave highest sensory score (7.65) and this was significantly different ($P \leq 0.05$) in comparisons to other percentages of KMS (CD = 0.365). The taste of Wood Apple powder treated with 0.5 per cent KMS was not acceptable by panel members. The potassium metabisulphite (KMS) of 0.3 per cent was selected for further study.

4.6.1.3 Standardization of the percentage of Aonla powder

Treated Wood Apple powder standardized with 0.3 per cent of KMS was mixed with Aonla powder in three different ratios of 90:10, 80:20 and 70:30, respectively. The sensory scores for Wood Apple Aonla powder were 6.56, 7.61 and 6.56 (treated Wood Apple powder: Aonla powder), respectively. The colour score of treated Wood Apple Aonla powder was non significantly different. The highest sensory score of 7.61 was found for 80:20 ratio of treated Wood Apple powder and Aonla powder (Table 4.43). The sensory score of 80:20 ratio was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.365).

Table 4.41: Standardization of the temperature of Wood Apple powder

Treatment	Colour	Flavour	Taste	Overall Acceptability
Temp (50°C)	6.80	6.90	6.55	6.75
Temp (60°C)	7.65	7.55	7.25	7.48
Temp (70°C)	6.80	6.90	6.55	6.75
Temp (80°C)	6.45	6.70	5.75	6.30
CD (5%)	0.361	NS	0.282	0.308
P value	0.03	0.14	0.00	0.01

Table 4.42: Standardization of the percentage of preservative (KMS) in Wood Apple powder

Treatment	Colour	Flavour	Taste	Overall Acceptability
KMS(0.1%)	6.95	6.60	6.65	6.73
KMS(0.3%)	7.85	7.55	7.55	7.65
KMS(0.5%)	6.85	6.70	6.50	6.68
CD (5%)	0.443	0.409	0.406	0.365
P value	0.04	0.03	0.02	0.01

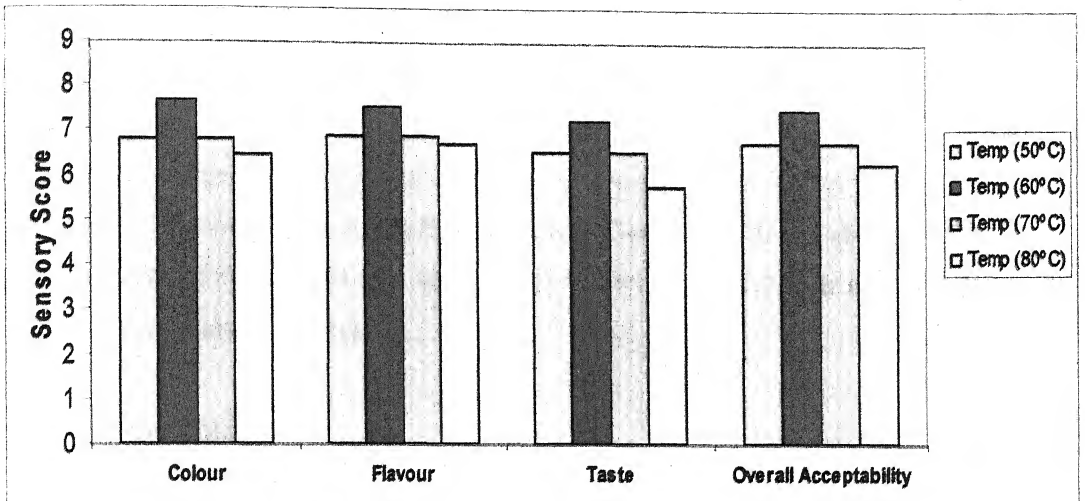


Fig. 4.28:Standardization of the temperature of Wood Apple powder

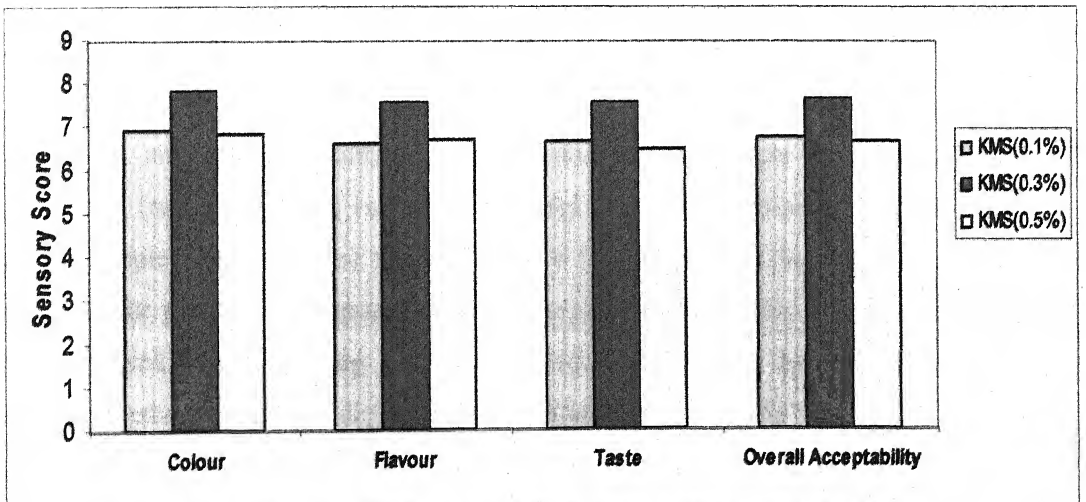


Fig. 4.29: Standardization of the percentage of preservative(KMS) in Wood Apple powder

4.6.1.4 Standardization of the percentage of Ginger powder

Treated Wood Apple powder was mixed with Ginger powder in three different ratios of 95:05, 90:10 and 85:15, respectively. The sensory scores for Wood Apple Ginger powder combination was 6.93, 7.81 and 6.80 (treated Wood Apple powder: Ginger powder), respectively. The colour score of treated Wood Apple Ginger powder was insignificantly different. The highest sensory score of 7.81 was found for 90:10 ratio of treated Wood Apple powder and Ginger powder (Table 4.44). The sensory score of 90:10 ratio was significantly different ($P \leq 0.05$) in comparison to other combinations (CD = 0.322).

4.6.2 Storage Study

The Wood Apple powders include variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) were stored for the storage study. All samples of Wood Apple powder were packed in air tight polythene and stored at room temperature for six months. Physico-chemical characteristics were evaluated at the interval of 0, 1, 2, 3, 4, 5 and 6 months during storage at room temperature (16-35°C) and physico-chemical, organoleptic and microbiological changes were observed.

4.6.2.1 *Physico-chemical characteristics*

The chemical constituents present in Wood Apple fruit influence the nutritional and storage qualities of the product. Wood Apple powder samples, variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) were analysed for proximate composition as per the approved methods. Moisture content was analysed by oven drying method, ash, carbohydrate, acid ascorbic content by titration method using 2, 6, dichlorophenol indophenol dye (Lane and Eynon, 1923), protein by micro-kjeldahl method, fat by soxhlet extraction method, calcium and phosphorus were determined by the procedures described by Ranganna (2003). All constituents were analysed at the end of 0, 1, 2, 3, 4, 5 and 6 months of storage at room temperature (16-35°C).

Table 4.43: Standardization of the ratio of treated Wood Apple powder with Aonla powder

Treatment	Colour	Flavour	Taste	Overall Acceptability
WAP:AP(90:10)	7.25	6.30	6.15	6.56
WAP:AP(80:20)	7.70	7.55	7.60	7.61
WAP:AP(70:30)	7.10	6.30	6.30	6.56
CD (5%)	NS	0.458	0.430	0.365
P value	0.16	0.01	0.00	0.00

Table 4.44: Standardization of the ratio of treated Wood Apple powder with Ginger powder

Treatment	Colour	Flavour	Taste	Overall Acceptability
WAP:GP(95:05)	7.00	6.90	6.90	6.93
WAP:GP(90:10)	7.55	7.85	8.05	7.81
WAP:AP(85:15)	6.95	6.90	6.55	6.80
CD (5%)	NS	0.384	0.477	0.322
P value	0.06	0.02	0.00	0.00

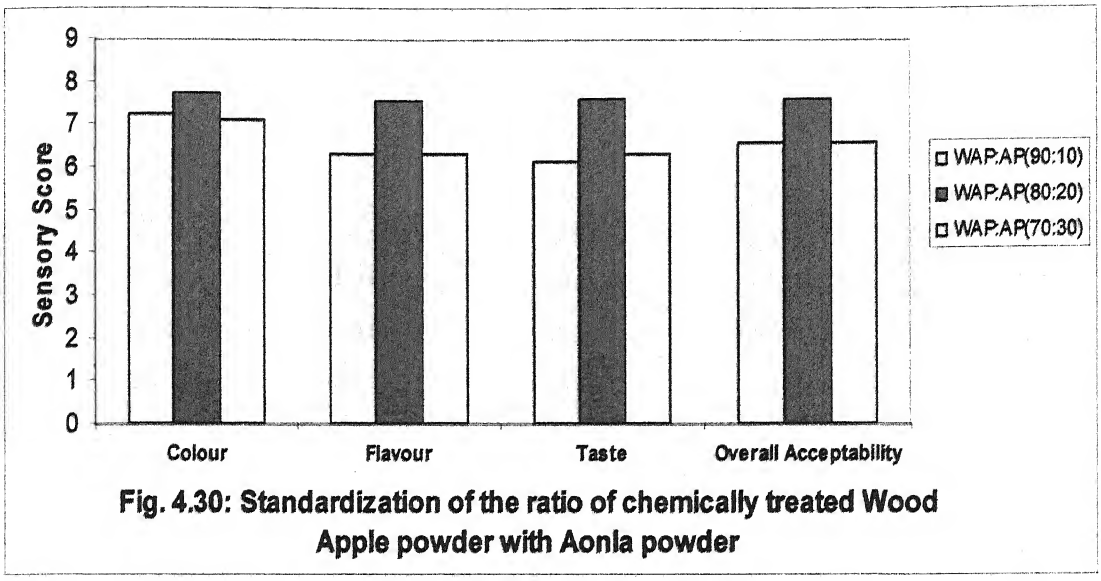


Fig. 4.30: Standardization of the ratio of chemically treated Wood Apple powder with Aonla powder

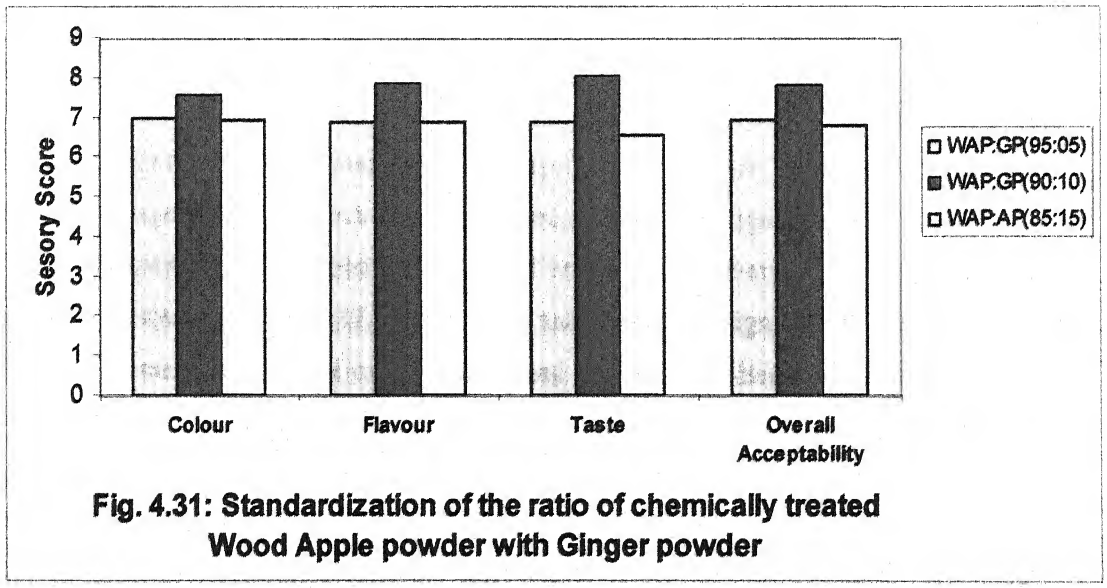


Fig. 4.31: Standardization of the ratio of chemically treated Wood Apple powder with Ginger powder

4.6.2.1.1 *Physico-chemical changes of variation one and variation two*

The powder samples were stored for six months and the changes in moisture, fat, protein, ash, carbohydrate, minerals and vitamin were observed. The results of the observations are presented in Table 4.45 and 4.46.

The moisture content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 3.22 and 2.48 per cent, respectively. During the storage period the moisture content showed an increasing trend in variation I and variation II. The changes in the moisture content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The initial moisture content of variation I and variation II was 3.22 and 2.48 per cent, respectively, which had increased to 3.48 and 2.62 per cent after 1 month of storage. The change in the moisture content of powder samples was significantly different ($P \leq 0.05$). The percentage of moisture content of variation I and variation II after 2 month was 3.75 and 3.06, respectively. There was significant difference ($P \leq 0.05$) in the moisture content of the product during the storage period. The percentage of moisture content of variation I and variation II after 3 month storage was 3.98 and 3.53, respectively and showed a significant difference ($P \leq 0.05$). The percentage of moisture content of variation I and variation II after 4 month storage was increased to 4.36 and 3.89, respectively. The results showed an increase in moisture content of powder samples with the storage period. The increment in the moisture content may be due to the absorption of moisture from the atmosphere during storage. The difference in the moisture content was significantly different ($P \leq 0.05$). The percentage of moisture content of variation I and variation II after 5 month of storage was 4.50 and 4.37, respectively and showed a significant difference ($P \leq 0.05$). The moisture content of variation I and variation II after 6 months of storage was increased to 4.55 and 4.75 per cent from initial moisture content of 3.22 and 2.48 per cent, repectively. The change in the moisture content was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.025 and 0.006). The moisture content in the sweetened Mango powder was increased from 0.87 to 0.98 per cent, respectively at room temperature during 12 months of storage as reported by Nanjundaswamy *et al.* (1976) while the moisture content of PVC Bottle packed Guava powder at room temperature was increased from 3.0 to 5.1 per cent during 6 months of storage observed by Khurdiya and Roy (1974). The results were found in conformity with the results observed in the present study.

The fat content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 1.30 and 1.35 per cent, respectively. During the storage period the fat content showed a slight change in variation I and variation II. The changes in the fat content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The fat content of variation I and variation II was decreased insignificantly from 1.3 and 1.35 per cent to 1.28 and 1.33 per cent, respectively during 6 months of storage. There was non significant difference in the fat content of the powder during the storage period.

The protein content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 6.62 and 6.32 per cent, respectively. No appreciable change in the protein content was observed during the storage. The changes in the protein content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The initial protein content of variation I and variation II was 6.62 and 6.32 per cent, respectively, which had decreased to 6.60 and 6.30 per cent after 6 months of storage. There was non significant difference in the protein content of the product during the storage period.

The carbohydrate content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 85.76 and 87.02 per cent, respectively. During the storage period the carbohydrate content showed a declining trend in variation I and variation II. The changes in the carbohydrate content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The initial carbohydrate content of variation I and variation II was 85.76 and 87.02 per cent, respectively, which had decreased to 85.50 and 86.88 per cent after 1 month of storage. The change in the carbohydrate content of powder samples was significantly different ($P \leq 0.05$). The percentage of carbohydrate content of variation I and variation II after 2 month was decreased to 85.24 and 86.44, respectively. There was significant difference ($P \leq 0.05$) in the carbohydrate content of the product during the storage period. The percentage of carbohydrate content of variation I and variation II after 3 month storage was decreased to 85.02 and 85.98, respectively and showed a significant difference ($P \leq 0.05$). The percentage of carbohydrate content of variation I and variation II after 4 month storage was 84.64 and 85.62, respectively. The carbohydrate content showed

regular decline in carbohydrate content. The difference in the carbohydrate content was significantly different (P≤ 0.05). The percentage of carbohydrate content of variation I and variation II after 5 month of storage was 84.51 and 85.15, respectively and showed a significant difference (P≤ 0.05). The carbohydrate content of variation I and variation II after 6 months of storage was decreased to 84.45 and 84.77 per cent from initial carbohydrate content of 85.76 and 87.02 per cent, respectively. The change in the carbohydrate content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.028 and 0.011).

The ascorbic acid content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 37.90 and 44.80 mg/100g, respectively. During the storage period the ascorbic acid content showed a declining trend in variation I and variation II. The changes in the ascorbic acid content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The initial ascorbic acid content of variation I and variation II was 37.90 and 44.80 mg/100g, respectively, which had decreased to 35.12 and 44.09 mg/100g after 1 month of storage. The change in the ascorbic acid content of powders sample was significantly different (P≤ 0.05). The value of ascorbic acid content of variation I and variation II after 2 month was decreased to 32.00 and 43.72 mg/100g, respectively. There was significant difference in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of variation I and variation II after 3 month storage was decreased to 30.65 and 43.53 mg/100g, respectively and showed a significant difference (P≤ 0.05). The value of ascorbic acid content of variation I and variation II after 4 month storage was 27.53 and 42.67 mg/100g, respectively. The ascorbic acid content showed regular decline in ascorbic acid content. The difference in the ascorbic acid content was significantly different (P≤ 0.05). The value of ascorbic acid content of variation I and variation II after 5 month of storage was 25.78 and 42.19 mg/100g, respectively and showed a significant difference (P≤ 0.05). The ascorbic acid content of variation I and variation II after 6 months of storage was decreased to 25.14 and 41.26 mg/100g from initial ascorbic acid content of 37.90 and 44.80 mg/100g, respectively. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 mg/100g level of significance (CD = 0.252 and 0.025). Khurdiya and Roy (1974) observed that the ascorbic acid content of PVC packed Guava powder was decreased from 905.9 to 83.1 mg/100g during 6

months of storage. The results were found in conformity with the results observed in the present study.

The ash content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 3.00 and 2.92 per cent, respectively. No appreciable change in the ash content was observed during the storage. The changes in the ash content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The ash content of the variation I and variation II was insignificantly changed from zero day (3.0 and 2.92 per cent) to 6 months of storage (3.02 and 2.94 per cent), respectively. The change in the ash content was non significant.

The calcium content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 276.66 and 253.25 mg/100g, respectively. During the storage period the calcium content showed a slight change in variation I and variation II. The changes in the calcium content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The calcium content of variation I and variation II was increased insignificantly from 276.66 and 253.25 mg/100g to 276.68 and 253.27 mg/100g, respectively during 6 months of storage. There was non significant difference in the calcium content of the product during the storage period.

The phosphorus content of the variation I (control sample) and variation II (treated Wood Apple powder) on zero day was 108.00 and 104.12 mg/100g, respectively. No appreciable change in the phosphorus content was observed during the storage. The changes in the phosphorus content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.45 and 4.46). The phosphorus content of the variation I and variation II was insignificantly changed from zero days (108.00 and 104.12 mg/100g) to 6 months of storage (108.04 and 104.14 mg/100g), respectively. The change in the phosphorus content was non significant.

Table 4.45: Changes in chemical constituents of Wood Apple powder (control) during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)
0 Days	3.22	1.40	6.62	85.76	37.90	3.00	276.66	108.00
1 Month	3.48	1.40	6.62	85.50	35.12	3.00	276.66	108.00
2 Month	3.75	1.39	6.61	85.24	32.00	3.01	276.67	108.01
3 Month	3.98	1.39	6.61	85.01	30.65	3.01	276.67	108.01
4 Month	4.36	1.39	6.60	84.64	27.53	3.01	276.67	108.02
5 Month	4.50	1.38	6.60	84.50	25.78	3.02	276.68	108.04
6 Month	4.55	1.38	6.60	84.45	25.14	3.02	276.68	108.04
CD (5%)	0.025	NS	NS	0.00	0.252	NS	NS	NS
P value	0.00	0.13	0.08	0.02	0.00	0.13	0.13	0.08

Table 4.46: Changes in chemical constituents of chemically treated Wood Apple powder during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)
0 Days	2.48	1.26	6.32	87.02	44.80	2.92	253.25	104.12
1 Month	2.62	1.26	6.32	86.88	44.09	2.92	253.25	104.12
2 Month	3.06	1.25	6.32	86.44	43.72	2.93	253.26	104.13
3 Month	3.53	1.25	6.31	85.98	43.53	2.93	253.26	104.13
4 Month	3.89	1.24	6.31	85.62	42.67	2.94	253.26	104.13
5 Month	4.37	1.24	6.30	85.15	42.19	2.94	253.27	104.14
6 Month	4.75	1.24	6.30	84.77	41.26	2.94	253.27	104.14
CD (5%)	0.006	NS	NS	0.011	0.0258	NS	NS	NS
P Value	0.00	0.08	0.08	0.00	0.00	0.08	0.13	0.13

4.6.2.1.2 *Physico-chemical changes of variation three and variation four*

The powder samples were stored for six months and the changes in moisture, fat, protein, ash, carbohydrate, minerals and vitamin were observed. The results of the observations are presented in Table 4.47 and 4.48.

The moisture content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 4.00 and 3.86 per cent, respectively. During the storage period the moisture content showed an increasing trend in variation III and variation IV. The changes in the moisture content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The initial moisture content of variation III and variation IV was 4.00 and 3.86 per cent, respectively, which had increased to 4.14 and 3.92 per cent after 1 month of storage. The change in the moisture content of powder samples was significantly different ($P \leq 0.05$). The percentage of moisture content of variation III and variation IV after 2 month was 4.20 and 4.18, respectively. There was significant difference ($P \leq 0.05$) in the moisture content of the product during the storage period. The percentage of moisture content of variation III and variation IV after 3 month storage was 4.32 and 4.26, respectively and showed a significant difference ($P \leq 0.05$). The percentage of moisture content of variation III and variation IV after 4 month storage was increased to 4.46 and 4.46, respectively. The results showed increase in moisture content of powder samples with increase the storage period. The increment in the moisture content may be due to the absorption of moisture from the atmosphere during storage. The difference in the moisture content was significantly different ($P \leq 0.05$). The percentage of moisture content of variation III and variation IV after 5 month of storage was 4.64 and 4.76, respectively and showed a significant difference ($P \leq 0.05$). The moisture content of variation III and variation IV after 6 months of storage was increased to 4.70 and 4.80 per cent from initial moisture content of 4.00 and 4.86 per cent,, respectively. The change in the moisture content was highly significant ($P = 0.00$) at 5 per cent level of significance (CD = 0.043 and 0.006).

The fat content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 1.30 and 1.35 per cent, respectively. During the storage period the fat content showed a slight change in variation III and variation IV. The changes in the fat content of powder samples were

assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The fat content of variation III and variation IV was decreased insignificantly from 1.30 and 1.35 per cent to 1.28 and 1.33 per cent, respectively during 6 months of storage. There was non significant difference in the fat content of the product during the storage period.

The protein content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 6.28 and 6.46 per cent, respectively. No appreciable change in the protein content was observed during the storage. The changes in the protein content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The initial protein content of variation III and variation IV was 6.28 and 6.46 per cent, respectively, which had changed insignificantly upto 6 months of storage 6.26 and 6.44 per cent. There was non significant difference in the protein content of the product during the storage period.

The carbohydrate content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 85.48 and 87.35 per cent, respectively. During the storage period the carbohydrate content showed a declining trend in variation III and variation IV. The changes in the carbohydrate content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The initial carbohydrate content of variation III and variation IV was 85.48 and 85.35 per cent, respectively, which had decreased to 85.34 and 85.29 per cent after 1 month of storage. The change in the carbohydrate content of powder samples was significantly different ($P \leq 0.05$). The percentage of carbohydrate content of variation III and variation IV after 2 month was decreased to 85.28 and 86.05, respectively. There was significant difference ($P \leq 0.05$) in the carbohydrate content of the product during the storage period. The percentage of carbohydrate content of variation III and variation IV after 3 month storage was decreased to 85.17 and 84.96, respectively and showed a significant difference ($P \leq 0.05$). The percentage of carbohydrate content of variation III and variation IV after 4 month storage was 85.03 and 84.77, respectively. The carbohydrate content showed regular decline in carbohydrate content. The difference in the carbohydrate content was significantly different ($P \leq 0.05$). The percentage of carbohydrate content of variation III and variation IV after 5 month of storage was

84.86 and 84.48, respectively and showed a significant difference (P≤ 0.05). The carbohydrate content of variation III and variation IV after 6 months of storage was decreased to 84.80 and 84.44 per cent from initial carbohydrate content of 85.48 and 85.35 per cent, respectively. The change in the carbohydrate content was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.044 and 0.032).

The ascorbic acid content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 55.86 and 42.48 mg/100g. During the storage period the ascorbic acid content showed a declining trend in variation III and variation IV. The changes in the ascorbic acid content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The initial ascorbic acid content of variation III and variation IV was 55.86 and 42.48 mg/100g, respectively, which had decreased to 54.28 and 42.12 mg/100g after 1 month of storage. The change in the ascorbic acid content of powder sample was significantly different (P≤ 0.05). The value of ascorbic acid content of variation III and variation IV after 2 month was decreased to 53.88 and 41.84 mg/100g, respectively. There was significant difference in the ascorbic acid content of the product during the storage period. The value of ascorbic acid content of variation III and variation IV after 3 month storage was decreased to 51.64 and 41.38 mg/100g, respectively and showed a significant difference (P≤ 0.05). The value of ascorbic acid content of variation III and variation IV after 4 month storage was 50.18 and 40.98 mg/100g, respectively. The ascorbic acid content showed regular decline in ascorbic acid content. The difference in the ascorbic acid content was significantly different (P≤ 0.05). The value of ascorbic acid content of variation III and variation IV after 5 month of storage was 48.92 and 40.54 mg/100g, respectively and showed a significant difference (P≤ 0.05). The ascorbic acid content of variation III and variation IV after 6 months of storage was decreased to 47.12 and 40.28 mg/100g from initial ascorbic acid content of 46.80 and 42.48 mg/100g. The change in the ascorbic acid content was highly significant (P= 0.00) at 5 mg/100g level of significance (CD = 0.006 and 0.006). The ascorbic acid content of sweetened Mango powder at room temperature was decreased from 18.9 to 2.7 mg/100g reported by Nanjundaswamy *et al.* (1976). The results were found in conformity with the results observed in the present study.

The ash content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 2.94 and 2.98 per cent, respectively. No appreciable change in the ash content was observed during the storage. The changes in the ash content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The ash content of the variation III and variation IV was insignificantly changed from zero days (2.94 and 2.98 per cent) to 6 months of storage (2.96 and 2.99 per cent), respectively. The change in the ash content was non significant.

The calcium content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 264.00 and 268.22 mg/100g. During the storage period the calcium content showed a slight change in variation III and variation IV. The changes in the calcium content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The calcium content of variation III and variation IV was increased insignificantly from 264.00 and 268.22 mg/100g to 264.02 and 268.24 mg/100g, respectively during 6 months of storage. There was non significant difference in the calcium content of the product during the storage period.

The phosphorus content of the variation III (treated Wood Apple Aonla powder) and variation IV (treated Wood Apple Ginger powder) on zero day was 98.20 and 102.80 mg/100g, respectively. No appreciable change in the phosphorus content was observed during the storage. The changes in the phosphorus content of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.47 and 4.48). The phosphorus content of the variation III and variation IV was insignificantly changed from zero days (98.20 and 102.80 mg/100g) to 6 months of storage (98.23 and 102.82 mg/100g), respectively. The change in the phosphorus content was non significant.

Table 4.47: Changes in chemical constituents of Wood Apple Aonla powder during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)
0 Day	4.00	1.30	6.28	85.48	55.86	2.94	264.00	98.20
1 Month	4.14	1.30	6.28	85.34	54.28	2.94	264.00	98.20
2 Month	4.20	1.30	6.28	85.28	53.88	2.94	264.01	98.22
3 Month	4.32	1.29	6.27	85.17	51.64	2.95	264.01	98.22
4 Month	4.46	1.29	6.27	85.03	50.18	2.95	264.02	98.22
5 Month	4.64	1.28	6.26	84.86	48.92	2.96	264.02	98.23
6 Month	4.70	1.28	6.26	84.80	47.12	2.96	264.02	98.23
CD (5%)	0.043	NS	NS	0.044	0.006	NS	NS	NS
P Value	0.00	0.08	0.08	0.00	0.00	0.08	1.00	0.98

Table 4.48: Changes in chemical constituents of Wood Apple Ginger powder during storage

Storage Period (Month)	Moisture %	Fat %	Protein %	Carbohydrate %	Ascorbic Acid (mg/100g)	Total Ash %	Calcium (mg/100gm)	Phosphorus (mg/100gm)
0 Day	3.86	1.35	6.46	85.35	42.48	2.98	268.22	102.80
1 Month	3.92	1.35	6.46	85.29	42.12	2.98	268.22	102.80
2 Month	4.18	1.34	6.45	85.05	41.84	2.98	268.22	102.81
3 Month	4.26	1.34	6.45	84.96	41.38	2.99	268.23	102.81
4 Month	4.46	1.34	6.44	84.77	40.98	2.99	268.23	102.81
5 Month	4.76	1.33	6.44	84.48	40.54	2.99	268.24	102.82
6 Month	4.80	1.33	6.44	84.44	40.28	2.99	268.24	102.82
CD (5%)	0.006	NS	NS	0.032	0.006	NS	NS	NS
P Value	0.00	0.13	0.08	0.00	0.00	0.54	0.08	0.13

4.6.2.2 *Organoleptic evaluation*

The acceptability of Wood Apple powder samples was evaluated by a ten member panel. The sensory feed back of powder samples were taken on a 9 point hedonic scale (Appendix V), from panel members, on the different quality parameters (colour, flavour, taste and overall acceptability). The sensory receptors did not perceive any unfavorable change in quality throughout the storage. The data of the same was analysed statistically to test the significance between the products (based on all parameters observed). Each parameter was compared for significant difference using the statistical analysis.

4.6.2.2.1 *Changes in the organoleptic qualities during storage*

The final product was stored for the determination of storage quality. The effect of storage on the organoleptic qualities of powder was assessed during a storage period of 6 months with an interval of 1 month (Table 4.49, 4.50, 4.51 and 4.52).

The score for colour of Wood Apple powder samples, variation III (control sample), variation IV (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) on zero day was 7.40, 7.50, 7.25 and 7.55, respectively. No appreciable change was observed during the storage period. The colour score showed a declining trend in Wood Apple powder through out the storage period. The changes in the colour score of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.49, 4.50, 4.51 and 4.52). The initial sensory score for colour of Wood Apple powder samples were 7.40, 7.50, 7.25 and 7.55, respectively, which had decreased insignificantly to 7.10, 6.90, 6.75 and 6.75, respectively during 6 month of storage. The changes in the colour score of powder samples were non significantly different.

The score for flavour of Wood Apple powder samples, variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) on zero day was 7.50, 7.40, 7.40 and 7.30, respectively. No appreciable change was observed during the storage period. The flavour score showed a declining trend in Wood Apple powder through out the storage period. The changes in the flavour score of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table

4.49, 4.50, 4.51 and 4.52). The initial sensory score for flavour of Wood Apple powder samples were 7.50, 7.40, 7.40 and 7.30, respectively, which had decreased insignificantly to 6.85, 6.90, 6.75 and 6.90, respectively during 6 month of storage. There was non significant difference in the flavour score of the product during the storage period.

The score for taste of Wood Apple powder samples, variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) on zero day was 7.40, 7.30, 7.15 and 7.25, respectively. No appreciable change was observed during the storage period. The taste score showed a declining trend in Wood Apple powder through out the storage period. The changes in the taste score of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.49, 4.50, 4.51 and 4.52). The initial sensory score for taste of Wood Apple powder samples were 7.40, 7.30, 7.15 and 7.25, respectively, which had decreased insignificantly to 6.75, 6.75, 6.80 and 6.90, respectively during 6 month of storage. The changes in the taste score of powder samples were non significantly different.

The score for the overall acceptability of the variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) on zero day was 7.42, 7.39, 7.26 and 7.36, respectively. During the storage period the overall acceptability score showed a declining trend in powder samples. The changes in the overall acceptability score of powder samples were assessed during the storage period of 6 months with an interval of 1 month (Table 4.49, 4.50, 4.51 and 4.52). The initial overall acceptability score of variation I, variation II, variation III and variation IV was 7.42, 7.39, 7.26 and 7.36, respectively, which had decreased to 7.33, 7.39, 7.24 and 7.27 after 1 month of storage. The change in the overall acceptability score of powder samples was significantly different ($P \leq 0.05$). The score for the overall acceptability of variation I, variation II, variation III and variation IV after 2 month was decreased to 7.11, 7.11, 6.94 and 7.11, respectively. There was significant difference ($P \leq 0.05$) in the overall acceptability score of the product during the storage period. The score for the overall acceptability of variation I, variation II, variation III and variation IV after 3 month storage was decreased to 7.08, 7.08, 7.06 and 7.06, respectively and showed a

significant difference (P≤ 0.05). The score for the overall acceptability of variation I, variation II, variation III and variation IV after 4 month storage was 6.99, 7.11, 6.96 and 7.06, respectively. The score for the overall acceptability showed regular decline in score for the overall acceptability. The difference in the overall acceptability score was significantly different (P≤ 0.05). The overall acceptability score of variation I, variation II, variation III and variation IV after 5 month of storage was 6.96, 6.99, 6.88 and 6.93, respectively and showed a significant difference (P≤ 0.05). The overall acceptability score of variation I, variation II, variation III and variation IV after 6 months of storage was decreased to 6.89, 6.84, 6.76 and 6.78 from initial overall acceptability score 7.42, 7.39, 7.26 and 7.36, respectively. The change in the score for the overall acceptability was highly significant (P= 0.00) at 5 per cent level of significance (CD = 0.074, 0.107, 0.011 and 0.115). It was found that the powder was acceptable after 6 month of storage.

4.6.2.3 *Microbiological analysis*

Microbial food safety is an essential component of food quality. Quality is a combination of characteristics that have significance in determining the degree of acceptability of the product to a consumer. The microbial quality of the powder samples was observed periodically. Microbiological changes were evaluated at the interval of 0, 1, 2, 3, 4, 5 and 6 months during storage at room temperature (16-35°C).

The total plate count, yeast and mould count and coliform count in variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) was found to be nil throughout the storage period at room temperature. This indicated that the

product remained safe microbiologically during storage and acceptable after 6 months of storage and no appreciable change was observed.

Table 4.49: Changes in sensory attributes in Wood Apple powder (control) storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	7.40	7.50	7.40	7.42
1 Month	7.40	7.35	7.25	7.33
2 Month	7.15	7.15	7.05	7.11
3 Month	7.15	7.10	7.00	7.08
4 Month	6.95	7.10	6.95	6.99
5 Month	6.95	7.00	6.95	6.96
6 Month	7.10	6.85	6.75	6.89
CD (5%)	NS	NS	NS	0.074
P Value	0.30	0.08	0.22	0.00

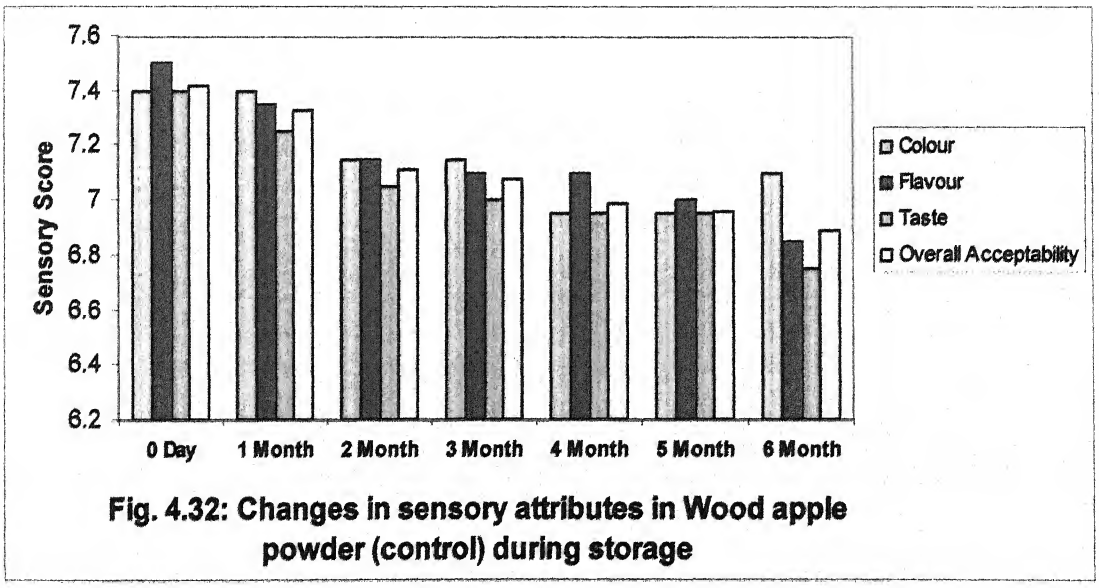


Fig. 4.32: Changes in sensory attributes in Wood apple powder (control) during storage

Table 4.50: Changes in sensory attributes in Wood Apple powder treated with KMS during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	7.50	7.40	7.30	7.39
1 Month	7.40	7.25	6.95	7.19
2 Month	7.15	7.20	7.00	7.11
3 Month	7.05	7.15	7.05	7.08
4 Month	7.45	6.95	6.95	7.11
5 Month	7.10	7.05	6.85	6.99
6 Month	6.90	6.90	6.75	6.84
CD (5%)	NS	NS	NS	0.107
P Value	0.14	0.45	0.59	0.03

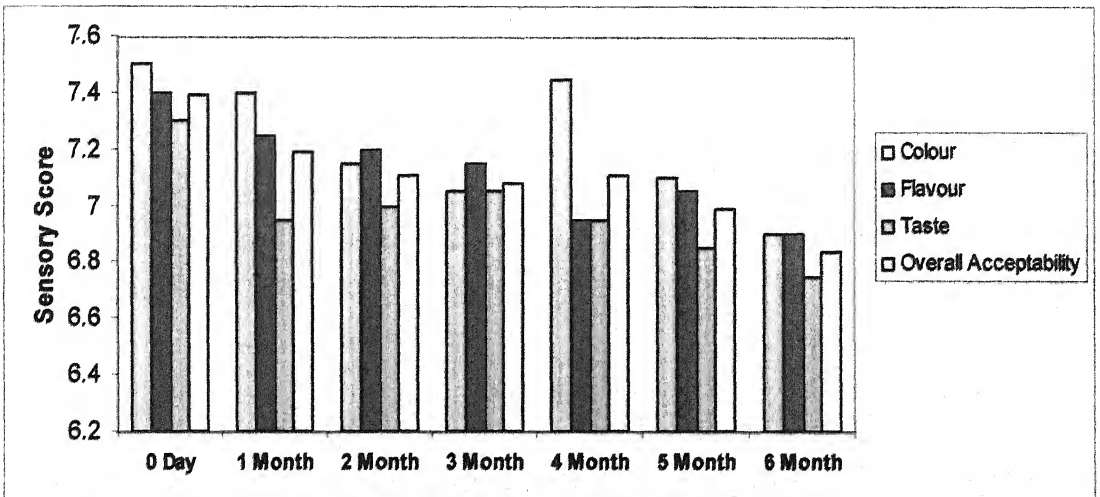


Fig. 4.33: Changes in sensory attributes in Wood Apple powder treated with KMS during storage

Table 4.51: Changes in sensory attributes in Wood Apple Aonla powder during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	7.25	7.40	7.15	7.26
1 Month	7.45	7.25	7.05	7.24
2 Month	7.10	6.80	6.95	6.94
3 Month	7.35	6.90	6.95	7.06
4 Month	7.05	7.00	6.85	6.96
5 Month	7.00	6.90	6.75	6.88
6 Month	6.75	6.75	6.80	6.76
CD (5%)	0.154	NS	NS	NS
P Value	0.05	0.11	0.90	0.10

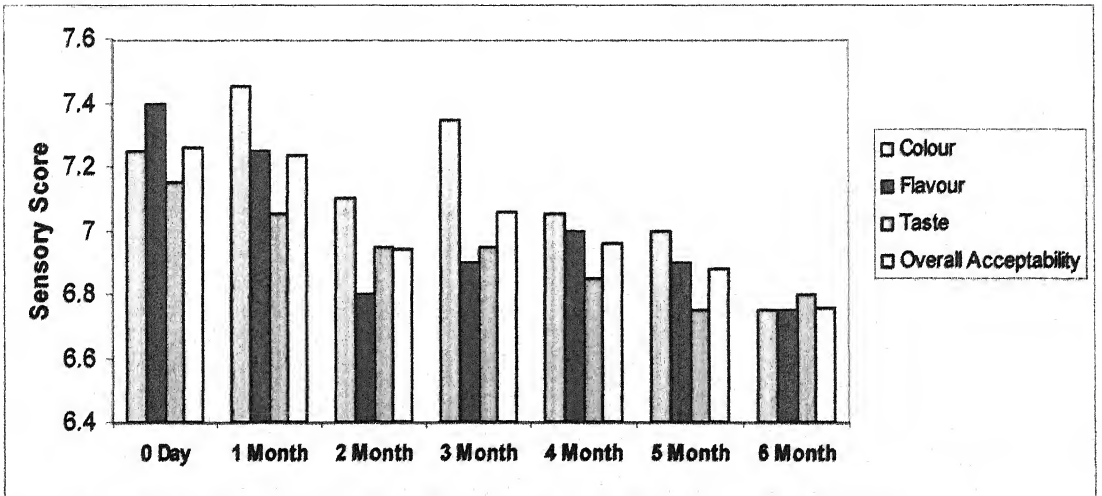


Fig. 4.34: Changes in sensory attributes in Wood Apple Aonla powder during storage

Table 4.52: Changes in sensory attributes in Wood Apple Ginger powder during storage

Treatment	Colour	Flavour	Taste	Overall Acceptability
0 Day	7.55	7.30	7.25	7.36
1 Month	7.35	7.40	7.10	7.27
2 Month	7.15	7.20	7.00	7.11
3 Month	7.15	7.10	6.90	7.06
4 Month	7.15	7.10	6.95	7.06
5 Month	6.85	7.10	6.85	6.93
6 Month	6.75	6.90	6.90	6.78
CD (5%)	NS	NS	NS	0.115
P Value	0.10	0.51	0.70	0.01

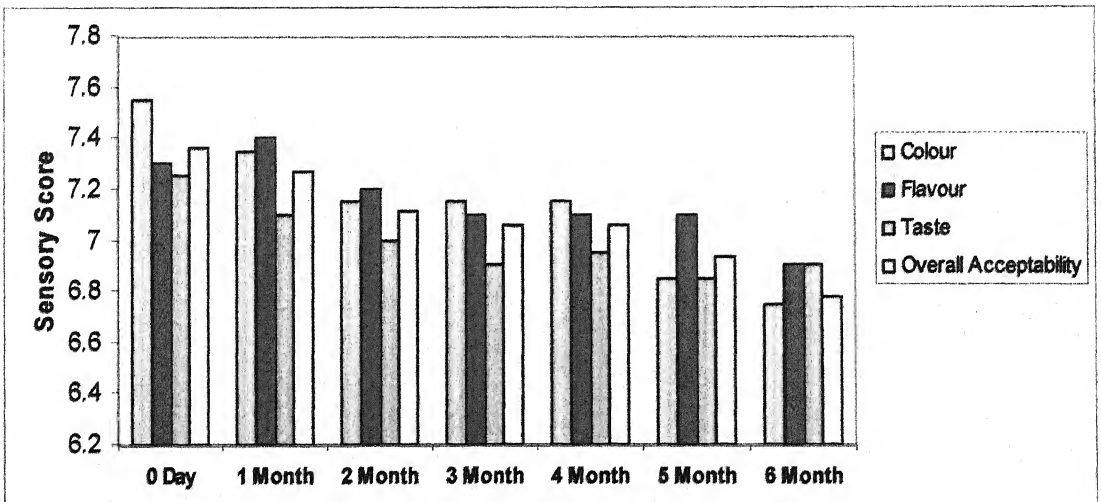


Fig 4.35: Changes in sensory attributes in Wood Apple Ginger powder during storage

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

Wood Apple (*Feronia limonia swingle)* is also know as elephant apple, monkey fruit, curd fruit, *kath bel* and other dialectal names in India. Wood Apple is a hardy fruit tree grown throughout the country for its edible sweet pulp. Wood Apple belongs to the family Rutaceae. It is a tropical deciduous species, native to India and Sri Lanka. It is commonly found in rural areas as a homestead tree. The fruit are very rich in iron, protein and minerals, especially calcium and phosphorus. The flesh is refreshing and, aromatic and tastes sour-sweet. The excellent flavor, nutritive value and medicinal characteristics of fruit indicate its good potentiality for processing into valuable products such as development of Wood Apple fruit bar and blended Wood Apple bar with Mango pulp, development of beverages includes Wood Apple nectar, blended beverages with orange flavour, Wood Apple based carbonated drink and development of powder treated with KMS and mixed with Ginger and Aonla powder.

1. For the extraction of Wood Apple pulp, flesh and water blends were prepared separately by manual mixing of flesh and water. The flesh and water in the ratio of 1:2 was easy for extraction. Wood Apple pulp was also treated with Enzyme (Tryzyme) but no acceptable change was observed in the juice.

2. Proximate composition of Wood Apple pulp showed moisture percentage of 72.4 per cent. Percentage of protein was 7.2, fat 2.07, carbohydrate 15.13 and ash 3.20, respectively.

3. Wood Apple pulp was rich in ascorbic acid content (66.40 mg/100g) and also in calcium content (188.80 mg/100g) while phosphorus content was 98.80 mg/100g.

4. Acidity of Wood Apple pulp was 3.18 per cent. TSS and pH of Wood Apple pulp was 13.2°Brix and 3.4, respectively.

5. Oleoresin was extracted from Wood Apple seeds with the help of solvent (hexane). Wood Apple seeds contained about 13.2 per cent oleoresin.

6. Wood Apple fruit bar prepared with standardized amount of sugar (30 per cent) and heated at 80 to 90°C. For the development of blended Wood Apple bar

Wood Apple pulp was blended with three different type of pulp i.e. Mango pulp, Ginger pulp and Papaya pulp in different ratios. Wood Apple and Mango pulp were mixed in 90:10, 70:30, 50:50 and 30:70 ratios, respectively. Wood Apple pulp and Ginger pulp were mixed in the ratio of 97:03, 95:05, 90:10 and 85:15 and Wood Apple and Papaya pulp were mixed in the ratio of 90:10, 70:30 and 50:50, respectively.

7. The sensory scores for overall acceptability of blended bar samples (Wood Apple Mango bar, Wood Apple Ginger bar and Wood Apple Papaya bar) were in the range of 6.94 to 7.62. The Wood Apple Mango bar with 50:50 (Wood Apple pulp: Mango pulp) ratio had highest sensory score of 7.62.

8. Studies showed that the moisture content of Wood Apple fruit bar and Wood Apple Mango bar decreased significantly ($P \leq 0.05$) from 17.40 and 14.80 to 13.52 and 10.95 per cent, respectively after 6 months of storage at room temperature.

9. During storage, significant changes were observed in protein of Wood Apple fruit bar and Wood Apple Mango bar from 2.20 and 1.98 to 2.18 and 1.84 per cent, respectively after 6 months of storage. The carbohydrate content (by difference) in bar samples increased significantly ($P \leq 0.05$) from 78.70 and 81.64 to 82.86 and 85.62 per cent, respectively.

10. During storage, significant ($P \leq 0.05$) changes were observed in acidity, TSS and pH. Acidity in Wood Apple fruit bar and Wood Apple Mango bar was increased from 2.35 and 2.44 to 2.48 and 2.55 per cent, respectively while TSS content in bar samples increased from 78.90 and 78.10 to 79.16 and 78.90°Brix, respectively. However, the pH value in bar samples was decreased from 3.90 and 4.32 to 3.63 and 4.07, respectively.

11. Non significant changes were observed in fat, ash, calcium and phosphorus during 6 months of storage. Total sugar, reducing sugar and non reducing sugar showed significant difference during storage period.

12. Textual characteristics (adhesiveness and cuttingness) of the Wood Apple fruit bar and Wood Apple Mango bar was changed significantly ($P \leq 0.05$). The adhesiveness of the bar samples were increased (-0.108 and -0.110 kg to -0.114 to -

0.116 kg) with increase in the storage period while cutting strength of the bar samples was decreased (2.80 and 3.04 kg to 2.16 and 2.12 kg) with increase in the storage period.

13. Sensory score for overall acceptability of Wood Apple fruit bar (control) and Wood Apple Mango bar was 7.79 and 8.29 at zero day and after 6 month decreased to 6.25 and 7.27, respectively. The acceptability of the bar was good after the 6 months of storage.

14. Total plate counts (TPC) in Wood Apple fruit bar (control) and Wood Apple Mango bar was nil at zero day and after 6 months storage TPC was 5.0×10^2 and 7×10^2cfu/g, respectively. Yeast and mould counts in Wood Apple fruit bar (control) and Wood Apple Mango bar was nil at zero day and after 6 months this was 1.0×10^2 and 1.5×10^2cfu/g, respectively. The bar remained safe microbiologically during storage and acceptable after 6 months of storage.

15. Wood Apple nectar was prepared by using 25 per cent Wood Apple pulp, 15 per cent sugar, 0.25 per cent citric acid and 0.03 per cent KMS (Pottasium metabisulphite).

16. Proximate composition of Wood Apple nectar changed significantly ($P \leq 0.05$) during 90 days of storage. Moisture content of Wood Apple nectar decreased significantly ($P \leq 0.05$) from 83.78 to 83.45 per cent, respectively during storage. Protein in Wood Apple nectar was 0.86 per cent at zero and after 90 days was decreased to 0.65 per cent. Ascorbic acid content in nectar decreased from 37.50 to 26.53 mg/100g, respectively during storage period. Acidity, pH and TSS content were also changed significantly ($P \leq 0.05$) from 0.53 to 0.55 per cent, 3.35 to 3.20 and 12.40 to 13.28°Brix, respectively during storage period.

17. Total sugar, reducing sugar and non reducing sugar in Wood Apple nectar was changed from 11.22 to 9.86 per cent, 4.78 to 5.32 per cent and 6.44 to 4.54 per cent, respectively after 90 days of storage.

18. During storage, non significant changes were observed in ash, calcium content and phosphorus content.

19. Sensory score for overall acceptability of Wood Apple nectar was 8.10 at zero day and decreased to 6.95 after 90 days of storage. The acceptability of the nectar was good after 90 days of storage. Microbiologically the nectar was safe to drink and no appreciable change was observed during 90 days of storage. Total plate count and yeast mould counts was nil at zero day and after 90 days the count was 7.5×10^2 and 1.5×10^2cfu/ml, respectively

20. Wood Apple pulp was used in the preparation of Wood Apple blended beverage (cocktail) at 25 per cent concentration. The standardized amount of sugar in blended beverage was 15 per cent and citric acid was 0.50 per cent. Flavored blended beverage was prepared by using orange flavour.

21. During storage, significant changes were observed in moisture, protein, ascorbic acid, acidity, pH, TSS, total sugar, reducing sugar and non reducing sugar while non significant changes were noticed in ash, calcium and phosphorus. Moisture content of blended beverage (control) and flavoured blended beverage was decreased significantly ($P \leq 0.05$) from 82.76 and 82.60 to 82.42 and 82.25 per cent, respectively. Protein in blended beverage (control) and flavoured blended beverage was 0.65 and 0.68 per cent at zero day and after 90 days was decreased to 0.40 and 0.48 per cent, respectively.

22. Ascorbic acid content in blended beverage (control) and flavoured blended beverage was decreased from 25.75 and 28.75 to 16.70 to 18.36 mg/100g, respectively during storage period. Acidity content in blended beverage (control) and flavoured blended beverage was 0.51 and 0.48 at zero day and after 90 days was increased to 0.55 and 0.53 per cent, respectively. The pH value of blended beverage (control) and flavoured blended beverage was decreased from 3.60 and 3.72 to 3.38 and 3.44, respectively while TSS content of blended beverage (control) and flavoured blended beverage was increased from 12.20 and 12.00 to 12.40 and 12.80, respectively.

23. During 6 month storage total sugar in blended beverage (control) and flavoured blended beverage was changed from 11.12 and 11.18 to 10.18 and 10.26 per cent, respectively while reducing sugar in blended beverage (control) and

flavoured blended beverage was increased from 4.94 and 4.70 to 5.30 and 5.08 per cent, respectively. The non reducing sugar in blended beverage (control) and flavoured blended beverage was 6.18 and 6.48 per cent at zero day and after 90 days was decreased to 4.88 and 5.18 per cent, respectively.

24. Sensory score for overall acceptability of blended beverage (control) and flavoured blended beverage was 8.02 and 8.19 at zero day and decreased to 6.43 and 6.61, respectively after 90 days storage period. The blended beverage was acceptable after 90 days of storage period. Microbiologically the beverage was safe to drink and no appreciable change was observed during 90 days of storage. Total plate counts in blended beverage (control) and flavoured blended beverage was nil at zero day and after 90 days was 8.0×10^2 and 9.0×10^2cfu/ml, respectively while yeast and mould counts in blended beverage (control) and flavoured blended beverage was nil at zero day and after 90 days was 3.0×10^2 and 2.0×10^2cfu/ml, respectively.

25. Wood Apple based carbonated drink was prepared by using 25 per cent Wood Apple pulp, 15 per cent sugar and the carbonation time was 3 min.

26. Proximate composition of Wood Apple carbonated drink was changed significantly ($P \leq 0.05$) during 90 days of storage. Moisture content of Wood Apple based carbonated drink was decreased significantly ($P \leq 0.05$) from 86.16 to 85.85 per cent, respectively during storage. Protein in Wood Apple carbonated drink was 0.79 per cent at zero and after 90 days was decreased to 0.66 per cent. Ascorbic acid content in carbonated drink was decreased from 22.54 to 16.93 mg/100g, respectively during storage period. Acidity, pH and TSS content were also changed significantly ($P \leq 0.05$) from 0.28 to 0.33 per cent, 3.44 to 3.18 and 12.20 to 13.20°Brix, respectively during storage period.

27. Total sugar, reducing sugar and non reducing sugar in Wood Apple carbonated drink was changed from 5.68 to 7.86 per cent, 3.48 to 4.24 per cent and 2.20 to 3.62 per cent, respectively after 90 days of storage.

28. During storage, non significant changes were observed in ash, calcium content and phosphorus content.

29. Sensory score for overall acceptability of Wood Apple carbonated drink was 7.86 at zero day and decreased to 6.41 after 90 days of storage. The acceptability of the Wood Apple based carbonated drink was good after 90 days of storage. Microbiologically the Wood Apple carbonated drink was safe to drink and no appreciable change was observed during 90 days of storage. Total plate counts and yeast mould counts was nil at zero day and after 90 days was 7.0 x 10^2 and 1.5 x 10^2cfu/ml, respectively.

30. Wood Apple pulp was used in the preparation of powder. Pulp dried at 60°C was found to get highest sensory score (7.48). Chemically treated Wood Apple powder was prepared by mixing of 0.3 per cent KMS. For mixed powder, chemically treated Wood Apple powder mixed with Aonla powder and Ginger powder. The best ratio for Wood Apple powder and Aonla powder was 80:20 ratio, scored highest sensory score (7.61) while the best ratio for Wood Apple powder and Ginger powder was 90:10, scored highest sensory score (7.81).

31. During storage, significant changes were observed in moisture, carbohydrate and ascorbic acid while non significant changes were noticed in fat, protein, ash, calcium and phosphorus. Moisture content of control sample (variation I) and chemically treated Wood Apple powder (variation II) was increased significantly ($P \leq 0.05$) from 3.22 and 2.48 to 4.55 and 4.75 per cent, respectively after 6 months of storage storage.

32. Carbohydrate content in variation I and variation II was 85.76 and 87.02 per cent, respectively at zero day and after 6 months was decreased to 84.45 and 84.77 per cent, respectively. The ascorbic acid content in variation I and variation II was decreased from 37.90 and 44.80 to 25.14 and 41.26 mg/100g, respectively after 6 month of storage, respectively.

33. Sensory score for overall acceptability of control sample (variation I) and chemically treated Wood Apple powder (variation II) was 7.42 and 7.39 at zero day and decreased to 6.89 and 6.84, respectively after 6 months of storage period. There was no acceptable changes were observed during storage.

34. Significant changes were noticed in moisture, carbohydrate and ascorbic acid while non significant changes were noticed in fat, protein, ash, calcium and phosphorus. Moisture content of Wood Apple Aonla powder (variation II) and Wood Apple Ginger powder (variation IV) was increased significantly ($P \leq 0.05$) from 4.00 and 3.86 to 4.70 and 4.80 per cent, respectively after 6 months of storage.

35. Carbohydrate content in variation II and variation IV was 85.48 and 85.35 per cent, respectively at zero day and after 6 months was decreased to 84.80 and 84.44 per cent. The ascorbic acid content in variation II and variation IV was decreased from 55.86 and 42.48 to 47.12 and 40.28 mg/100g, respectively after 6 month of storage.

36. Sensory score for overall acceptability of Wood Apple Aonla powder (variation II) and Wood Apple Ginger powder (variation IV) was 7.26 and 7.36 at zero day and decreased to 6.76 and 6.78, respectively after 6 months of storage period. No acceptable changes were observed during storage.

37. The total plate count, yeast and mould count and coliform count in variation I (control sample), variation II (treated Wood Apple powder), variation III (Wood Apple Aonla powder) and variation IV (Wood Apple Ginger powder) was found to be nil throughout the storage period at room temperature. This indicated that the product remained safe microbiologically during storage and acceptable after 6 months of storage and no appreciable change was observed.

It can be concluded that Wood Apple pulp has all the essential nutrients and thus can be recommended for regular use in daily diet to contribute various nutrients. Further, Wood Apple bar, Wood Apple nectar, blended beverage, Wood Apple based carbonated drink and Wood Apple powder are well accepted also as they are good in nutrient content, hence can be recommended for household consumption. Since these products can be easily prepared with locally available ingredients, tribal population may be trained and motivated to use this fruit for commercial use.

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APPENDIX

APPENDIX-I

SENSORY SCORE CARD FOR WOOD APPLE BAR ON 9-POINT HEDONIC SCALE

Name of the Panelist ..... **Faculty/Student**

Experiment No. ..... **Date** .....

You are requested to evaluate the following sample of Wood Apple bar. Wood Apple fruit is a hard fruit it has sour taste. Wood apple bar should be sweet and sour in taste, chewy with pleasant flavour and acceptable texture. The colour the product should be light brown to dark chocolate brown.

Kindly evaluate the samples of fruit bar on the basis of following 9-point hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No.	Sensory Attributes					
	Colour	Flavour	Taste	Body and Texture	Chewness	Overall Acceptability

Remarks.....

.....

(Signature)

APPENDIX-II

SENSORY SCORE CARD FOR WOOD APPLE NECTAR ON 9-POINT HEDONIC SCALE

Name of the Panelist ..... **Faculty/Student**

Experiment No. ..... **Date** .....

You are requested to evaluate the following sample of Wood Apple nectar. Wood Apple fruit is a hard fruit it has sour taste. Wood apple nectar should be sweet and sour in taste, chewy with pleasant flavour and acceptable taste. The nectar is a fruit drink, which is used as refreshment.

Kindly evaluate the samples of fruit nectar on the basis of following 9-point hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No.	Sensory Attributes			
	Colour	Flavour	Taste	Overall Acceptability

Remarks.....

.....

(Signature)

APPENDIX-III

SENSORY SCORE CARD FOR WOOD APPLE BLENDED BEVERAGE (COCKTAIL) ON 9-POINT HEDONIC SCALE

Name of the Panelist ..... **Faculty/Student**

Experiment No. ..... **Date** .....

You are requested to evaluate the following sample of Wood Apple blended beverage (cocktail). Wood Apple fruit is a hard fruit it has sour taste. Wood apple blended beverage should be sweet and sour in taste, chewy with pleasant flavour and acceptable taste. The blended beverage is a fruit drink, which is used as refreshment. Kindly evaluate the samples of wood apple blended beverage on the basis of following 9-point hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No.	Sensory Attributes			
	Colour	Flavour	Taste	Overall Acceptability

Remarks.....

.....

(Signature)

APPENDIX-IV

SENSORY SCORE CARD FOR WOOD APPLE BASED CARBONATED DRINK ON 9-POINT HEDONIC SCALE

Name of the Panelist ..... **Faculty/Student**

Experiment No. ..... **Date** .....

You are requested to evaluate the following sample of Wood Apple based carbonated drink. Wood Apple fruit is a hard fruit it has sour taste. Wood apple carbonated drink should be sweet and sour in taste, chewy with pleasant flavour and acceptable taste. The carbonated drink is a fruit drink, which is used as refreshment.

Kindly evaluate the samples of Wood Apple based carbonated drink on the basis of following 9-point hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No.	Sensory Attributes			
	Colour	Flavour	Taste	Overall Acceptability

Remarks.....

.....

(Signature)

APPENDIX-V

SENSORY SCORE CARD FOR WOOD APPLEPOWDER ON 9-POINT HEDONIC SCALE

Name of the Panelist ..... **Faculty/Student**

Experiment No. ..... **Date** .....

You are requested to evaluate the following sample of Wood Apple powder. Wood Apple fruit is a hard fruit it has sour taste. The colour of the product should be light brown to chocolate brown

Kindly evaluate the samples of Wood Apple powder basis of following 9-point hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Sample No.	Sensory Attributes			
	Colour	Flavour	Taste	Overall Acceptability

Remarks.....

.....

(Signature)

VITA

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